RECREATION AND PRESERVATION VALUATION ESTIMATES FOR FLATHEAD RIVER AND LAKE SYSTEM

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December 30, 1982

This project was financed, in part, with Federal Funds from the Environmental Protection Agency under grant number R008224011. The contents do not necessarily reflect the views and policies of the Environmental Protection Agency.

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ACKNOWLEDGMENTS

Particular appreciation goes to Ron Cooper of the Flathead River Basin Study and to Pat Graham of the Montana, Department of Fish, Wildlife and Parks for their cooperative efforts throughout the study as well as their comments on a previous draft. Constructive comments were also obtained from Wade Fredenberg, John Loomis, Terry Raettig and John Duffield. Computer programming for the preservation estimates was done by John McQuown. I am particularly grateful to Richard Walsh, who is my co-author of Section VI on preservation values.

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ABSTRACT

A regional recreation demand and benefits model, developed initially for the Pacific Northwest, is extended to include Western Montana, with special focus on the Flathead River and Lake System. The model is used to estimate total recreation use on the River and Lake for 1981 by activity for fishing, camping, boating and swimming and to place a monetary value on this use. During 1981 there were approximately 740 thousand visitor days with a total consumer surplus of $5 million dollars. During the summer of 1981 an extensive on-site survey was taken to estimate total recreation use. Finally, a mail survey of four cities in Montana was conducted to estimate non-user values of the Lake and River system. Annual option, existence, and bequest values are estimated to be approximately $97 million.

Section I. INTRODUCTION

The main objective of this study is to construct valuation estimates of the Flathead Lake and River system. Although the Lake and River system has multiple uses and therefore values, this study will focus on recreation demand and value and also on preservation values. The recreation activities include fishing, camping, boating and swimming. Non-use preservation values to be estimated include option, existence, and bequest values. Option value is the willingness to pay to avoid irreversible loss of the opportunity for future access to natural environments for recreation use. Bequest value is the willingness to pay for the satisfaction derived from endowing future generations with a natural environment. Existence value is the willingness to pay for the knowledge that a natural environment is preserved even though no recreation use is contemplated.

The Flathead River and Flathead Lake together provide a major focus for recreational activities within the basin. The forks of the Flathead, as well as a portion of the mainstem, are designated components in the National Wild and Scenic River System. Flathead Lake with its 126,000 surface acre area, is the largest natural lake in the West. The entire system is known for its high quality. The study area inclues Flathead Lake, the mainstem Flathead River above Flathead Lake (55.3 miles), the North Fork Flathead River in the U.S. (58.3 miles), and the Middle Fork of the Flathead River (91.0 miles). The South Fork of the Flathead River is not included in the study area because it includes impounded water.

This study focuses on recreation values and preservation values, where each is defined as willingness to pay. Section II presents the reasons for focusing on these values, and for excluding other values such as the regional economic impact of the study area. An on-site participation survey was conducted by Montana, Fish, Wildlife and Parks to obtain data to estimate Lake and River recreation use. These data are analyzed in Section III, where total annual recreation days are estimated for camping, fishing, boating and swimming.

A regional recreation demand and benefits model is used to estimate demand and value of Flathead River and Lake. The model was constructed for the U.S. Environmental Protection Agency to evaluate the recreation benefits of improving water quality in the Pacific Northwest.[1] The model is described in Section IV. In Section V, the model is applied to estimate consumers' surplus and recreation demand of the study area.

A mail survey of Montana residents is used to estimate the willingness to pay to preserve water quality. Section VI describes the survey results and presents total preservation value estimates. Total annual willingness to pay to protect water quality in Flathead River and Lake by both Montana and non-Montana residences is estimated to be $97 million in 1981.

Total estimated annual recreation visitor days at the study area beginning May 15, 1981 was 680,002. Of this total 92 per cent occurred on the Lake, and 58 per cent of the activity were fishing days. Total annual value of this recreation use is estimated to be $5.05 million. The preservation and recreation use values total to $102.35 (97.3 + 5.05) million per year.

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[1] For a description of the model see, Ronald J. Sutherland, "A Regional Approach to Estimating Recreation Benefits of Improved Water Quality," Journal of Economics and Environmental Management, Vol. 9, No. 3, September, 1982, pp. 248-262. Also see, Ronald J. Sutherland, "A Regional Recreation Demand and Benefits Model,"Working Paper, U.S. Environmental Protection Agency, Corvallis, Oregon, 1982.

Section II. A DEFINITION OF ECONOMIC VALUE

A. Types of Benefits

The existing high level of water quality in Flathead River and Lake results in benefits to local residents, to users of the resource, and to residents of the multi-state region, including neighboring Canadian provinces. The existing level of water quality has numerous types of benefits. Recreation use and the regional economic impact of those who visit the study region are obvious examples. The water is also used for drinking, watering livestock, and it also has an aesthetic value. The types of values and uses of water considered in this study, and their method of estimation, are determined by the Request For Proposal, by the NED Benefit Evaluation Procedures of the Water Resources Council, and by the presently accepted methods of estimating recreation and preservation values.

The Request For Proposal (RFP), from the Flathead River Basin Study defined the main objective of the study to be the estimation of the value of water based recreation, including fishing, boating and swimming in the Flathead Lake and River System. According to the RFP, the methodology should be compatable with the "Procedures for Evaluation..." of the Water Resources Council.[2] The RFP also stated that a mail survey should be conducted, and option and existence values should be considered. This analysis concentrates on recreation and preservation (option and existence) values, because these values were defined to be the main objective of the study. An appropriate concept of the value of water quality is not the value of water per se, but the value of the use of water. By focusing on the use of water, multiple uses can be identified. Also,

[2] "Procedures for Evaluation of National Economic Development N.E.D. - Benefits and Costs in Water Resources Planning level C - Final Rule" December 14, 1979, Water Resources Council.

though, it is empirically feasible to place a value on human activities, including the use of water. The water quality benefits literature has identified numerous uses of water that may be impacted by changes in water quality. Tihansky (1973, p. 132) lists fourteen uses of water. Various uses of water may be particularly important in different cases, but in general the main use of water that is impacted by quality changes is recreation. Of the total dollar benefits of improving water estimated by Freeman (1979b) over half are from improved recreation. The decision by the Flathead River Basin Study to concentrate this analysis on recreation benefits is consistent with the results of the water quality benefits literature.

This analysis focuses on recreation benefits but also includes preservation values, such as option, bequest and existence. By not estimating all possible benefits of existing water quality, the benefits estimated here are likely to understate the total value of the Lake and River system. For instance, there are a large number of summer homes and year around residences near the shore of Flathead Lake. Property values of these residences would be adversely affected if water quality would be so degraded as to affect Lake uses.

Property values are affected by water quality, and they are not considered in this study. However, a component of property values is implicitly being considered here. Lake front property has a high value for aesthetic reasons, but also because these property owners have easy access to the Lake for recreation use. By estimating recreation benefits, part of the property value due to water quality is also being estimated.

Recreation use in the study area results in a regional economic impact in terms of income and employment. Regional impacts are not considered in this study, even though they have a positive economic effect on the region. The Water Resources Council defines benefits in terms of national economic development (NED). Regional economic impacts do not necessarily impact NED. Regional economic impacts are likely to come at the expense of other regions, and hence reflect a redistribution of NED and not a net change.

B. The Conceptual Nature of Benefits

The proper conceptual measure of recreation benefits as well as preservation values is consumer surplus. The correctness of this measure is confirmed by the recreation research literature, and by Water Resources Council, and it is included in the RFP of the Flathead River Basin Study. The RFP explicitly states that the overall study design should use the consumer surplus valuation technique.

The Water Resources Council has set forth criteria to be used by all Federal agencies undertaking water resources development. These criteria were strongly recommended before the Carter Administration, and became legally binding under President Carter. With the Reagan Administration the NED Benefit Evaluation Procedures are no longer legally binding. The NED Procedures are followed in this analysis because the RFP explicitly recommends them and because they reflect the state-of-the-art in water resource evaluation techniques.

The Water Resources Council (1979, p. 72950) states that the benefits of a recreation project are measured in terms of the willingness to pay for the project. Total willingness to pay includes any use or entry fees actually paid for site use plus any unpaid surplus value enjoyed by consumers. Total willingness to pay is measured as the area under the recreation site demand curve up to the point of total use. With the exception of camping at state parks and private campgrounds, there are no use or site fees. For swimming, fishing, and boating not associated with campgrounds, total willingness to pay is also a net willingness to pay and consumers' surplus. Recreation benefits are therefore measured as the total area under the recreation site demand curve, and user fees are deducted in the case of camping where they are charged.

The appropriate measure of benefits in this study is existing recreation benefits. Should water quality in Flathead River and Lake be degraded so as to restrict recreation use, the existing benefits to recreationists would be foregone or reduced.

Section III. ON-SITE SURVEY RESULTS AND RECREATION PARTICIPATION ESTIMATES

From May 15, 1981 through the following twelve months, personnel from the Montana Department of Fish, Wildlife and Parks conducted a recreation survey on Flathead River and Lake.[3] The Lake component of the survey included car counters placed at ten entrances, on-shore interviews at several state campgrounds, and interviews and counts taken from a boat. After September 7, 1981 the survey effort was significantly reduced, but so was the level of recreation. One purpose of the survey was to provide fisherman harvest information for the State of Montana. A second purpose was to provide data to estimate total recreation days by type of activity on the Lake and River system.

The first part of this section presents a summary of the Lake survey data. These data serve as inputs in estimating total recreation days; they include input data in the regional recreation model; and finally they contribute to the recreation data base of the region. The second part of this section presents estimates of total recreation participation at Flathead Lake for one year beginning May 15, 1981. Demand estimates for the River will be presented in the final part of this section. Since these estimates were prepared by Montana Fish, Wildlife and Partks, the methodology will not be discussed.

A. On-Site Survey Data

A summary of the on-site survey data will be presented in the order of the questions on the questionnaire. Data are presented for the entire one-year sample period, but where appropriate, summer and non-summer data will be presented separately. Most of the swimming, camping and boating occurs during the summer, but considerable Lake fishing occurs during other seasons.

[3] See the reports by Graham and Fredenberg (1982) and by Fredenberg and Graham (1982 a and b).

Interviews were conducted by boat and on-shore in public campgrounds. The first question asked whether the recreationist owned or rented a home on the Lake. The purpose of this question was to determine the proportion of recreationists who travel to the Lake versus those who reside there a major part of the summer. Recreation value per trip is estimated for those who travel to the Lake by a regional recreation demand and benefits model. This model uses the travel-cost approach and is therefore not applicable to those who reside on the Lake. Those who reside on the Lake will be assumed to have the same value per day as the average of those who travel to the Lake. The responses to this question indicate that most of those interviewed on-shore at public accesses do not own or rent a home on the Lake.

TABLE I

DO YOU OWN OR RENT A HOME ON FLATHEAD LAKE OR RIVER?

Response		Boat Interview	Shore Interview	Total Interviews
Don't Know		945	398	1,343
Yes		489	208	697
No		386	1,860	2,246
	Total	1,820	2,466	4,286

However, more of the boaters reside on the Lake than travel to it. The large number of "Don't Know" responses by boaters is due to a large number of boaters not being questioned. These boaters were counted as being surveyed because they provided information by their location (such as crossing a car counter) even though they were not questioned. The total sample size is 4,286, of which about 75 per cent was obtained during the summer (where the summer is from May 15 through September 7).

Recreationists were next asked whether they would visit other recreation sites on this trip. As seen in Table II, the large majority of on-site and boat

TABLE II

DID YOU OR WILL YOU VISIT OTHER RECREATION SITES ON YOUR TRIP?

Response	Boat Interview	Shore Interview	Total Interviews
Don't Know	1,098	408	1,506
Yes	41	455	496
No	679	1,602	2,281
Total	1,818	2,465	4,283

respondents indicated that they would not visit other sites on this trip. Where recreation trips are multi-destination, the travel-cost approach assigns all the recreation value to the destination being studied instead of allocating it across destinations. Since Flathead Lake was the only destination of the large majority of those sampled, we infer that the travel-cost model does not contain a bias due to multi-destination trips. The presence of Glacier National Park and other attractions in the region necessitated checking for multi-destination trips.

If other sites are visited while on a trip to the Lake, the travel-cost model may not contain a bias if visiting the Lake is the main purpose of the trip. As depicted in Table III, the very large majority of those who recreate at Flathead Lake do so as the main purpose of their trip.

TABLE III

IF OTHER SITES WERE VISITED WAS VISITING FLATHEAD LAKE THE MAIN PURPOSE OF THE TRIP?

Response	Boat Interview	Shore Interview	Total Interviews
Don't Know	1,064	325	1,389
Yes	739	1,783	2,522
No	17	359	376
Total	1,820	2,467	4,287

The above two questions were used to estimate the percent of the visitors whose behavior could be modeled by the travel-cost approach, and also as a screening device to eliminate those responses which might not conform to the travel-cost model. Of the total sample of 4286, only those who indicated that recreating at Flathead Lake was the main purpose of their trip were included in the following tabulations. Also, those who did not know whether they would visit other sites while visiting the Lake, were deleted from the sample. This screening device reduced the summer sample from 3247 to 1948 cases. The non-summer sample was correspondingly reduced from 1039 to 445 cases. The total usable one-year sample is 2393 cases.

One input in the travel-cost recreation model is the cost per person per vehicle mile. An input in this calculation is the average number of persons per vehicle is 2.69. This number will be used in Section V to estimate travel cost demand curves for the study area.

Calculating travel cost per day requires an estimate of the average length of stay per trip. Visitors were therefore asked to indicate the number of days they have or would spend at the study area on this trip. The sample mean length of stay for the summer period is 1.77 days. About 74 per cent of the visits are one day visits, and 95 per cent of the respondents indicated a visit of less than one week.

A particularly important objective of the site survey was to estimate the allocation of activities between camping, fishing, boating, and swimming. The sample data presented in Table IV show that camping and fishing are particularly popular, but during the non-summer months, fishing is the dominant activity. However, as shown subsequently, the sample contains a very large share of the campers. Where, for instance, 3 people indicated that each would fish

TABLE IV

ALLOCATION OF RECREATION DAYS

Activity	Summer Days	Summer Percent	Non-Summer Days	Non-Summer Percent
Boat fishing	3,249	31.70	817	72.45
Shore fishing	265		243	
Swimming	1,138	10.27	13	0.89
Camping	3,690	33.29	284	19.41
Picnicking	892	8.05	17	1.16
Boating	1,852	16.71	89	6.08
Total	11,086	100.00	1,463	100.00

for 4 days, 12 fishing days would be recorded. If, during this same trip, some people would also swim, the number of swimming days would be counted accordingly. Since more than one activity may be participated in during one day, the total estimated recreation days would exceed the total number of days at the Lake. The problem of multiple activities is particularly serious with camping, because campers generally engage in other activities while at the Lake.

A component of travel-cost is the operating cost per vehicle, which is heavily influenced by vehicle fuel efficiency. Rather than relying upon national estimates of fleet fuel efficiency, the fuel efficiency of the vehicles used by recreationists was estimated. The question simply asked the recreationists the miles per gallon they received on this trip. The sample mean estimate is 16.686 miles per gallon.

An important input in the total use estimate is the proportion of visits which cross a car counter. Of the usable summer sample of 1935 cases, 1294 or 66.9 per cent crossed a car counter while 641 or 33.1 per cent did not cross a counter. However these data over-represent the car counters because most of the interviews were conducted in campgrounds and all these campgrounds had car counters.

Of those who cross counters, it is important to estimate the number of vehicles which may cross more than one counter in a single day. The sample mean number of car counter crossings per day is 1.21. This number reflects exits and not entrances and it reflects only summer data. To convert (pneumatic) car counter data to recreation days, it is necessary to convert the number of vehicle axles (which are counted) to the number of vehicles. However, 8 of the 11 car counters were electronic, where such a conversion is unnecessary. The mean number of axles per vehicle in the summer survey is 2.468.

The final question asked is the origin of the trip. The results are presented on the following Table V. As depicted in Table V, about 59 percent of the visits to the Lake emanate from Flathead or Lake County, the two counties which contain Flathead Lake. Only about 2 percent of the visitors come from Canada. Missoula, which is 115 miles from the Lake, sends about 15 percent of the recreationists. Other major cities in Montana, such as Helena, Great Falls, Bozeman, and Butte, which are of greater distance to the Lake send very few visitors. About 13 percent of the Lake visitors come from outside Montana during the summer, and about 10 percent during the non-summer period. Overall, the dominant form of recreation is one-day fishing trips originating from Flathead or Lake counties and relatively short camping trips with multiple acrivities, such as swimming, boating and fishing.

B. Recreation Participation on Flathead Lake

The recreation survey conducted on Flathead Lake during the twelve months beginning in May 1981 resulted in a sample from which total annual recreation days are estimated. The sampling and estimation methodologies are similar to those used by the U.S. Forest Service and by the Army Corps of Engineers, but

TABLE V

FREQUENCY DISTRIBUTION OF TRIP ORIGINS TO FLATHEAD LAKE

Code Number	Origin	Summer Data Absolute Frequency	Summer Data Relative Frequency	Non-Summer Data Absolute Frequency	Non-Summer Data Relative Frequency
1	Cranbrook	6	.003	0	.000
2	Calgary	29	.015	3	.007
3	Canada, not 1 or 2	26	.014	2	.005
4	Lake County	359	.187	87	.216
5	Flathead County	778	.406	183	.454
6	Missoula	286	.149	55	.136
7	Helena	13	.007	0	.000
8	Great Falls	23	.012	2	.005
9	Bozeman	3	.001	2	.005
10	Butte	14	.007	0	.000
11	Anaconda	1	.000	0	.000
12	Montana	122	.064	27	.067
13	Outside Montana	256	.133	42	.104
14	Outside U.S.	2	.001	0	.000
0	Don't Know	30	-	42	-
	Total	1,948	1.000	403	1.000

Note: The "Don't Know" responses were deleted when computing totals and relative frequencies.

they are not identical.

The objective is to estimate total annual recreation activity days on Flathead Lake by type of activity. Traffic counters were used to estimate total vehicles at selected Lake entrances. A random sample of Lake recreation was used to estimate the percent of recreators who crossed car counters. These two estimates are combined to estimate total recreation days. Lake users were also sampled to determine the allocation of their activities. These sample estimates are then used to allocate total recreation days between camping, fishing, boating, and swimming.

Car counter results for the summer and non-summer period are depicted in Table VI. Where necessary, these results are corrected for vehicles with more than two axles and also for non recreation vehicles. The critical estimate is the total of 37,737 vehicles that crossed the counters during this one-year period. Of this total only 4,011 vehicles crossed counters during the non-summer period. Recreation use decreases after the summer and only two car counters, rather than ten, were used.

TABLE VI

TOTAL VEHICLE COUNT FOR SELECTED SITES ON FLATHEAD LAKE

Site Name		Vehicle Count Summer	Vehicle Count Non-Summer
Wayfarers		13,873	1,677
Big Arm (1)		1,111	221
Big Arm (2)		5,166	-
Yellow Bay		5,305	1,095
West Shore		5,002	257
Finley Point		3,004	117
Big Fork		1,793	550
Woods Bay		1,755	86
Elmo		1,588	150
Walstad		741	16
Somers		1,433	702
	Total	40,821	4,853
Corrected for multiple crossings		33.736	4,011

The correction for multiple crossings is obtained by dividing total crossings by 1.21, which is the sample mean number of car crossings per vehicle. The total annual vehicle count is 33,736 + 4,011 = 37,747.

The previous part of this section presents the site survey estimate of an average of 2.69 persons per vehicle of those persons recreating at Flathead Lake. Multiplying persons per vehicle and number of vehicles for the summer and non-summer period yields 90,750 and 10,790, which are the number of recreationists who crossed car counters. The summer recreation survey results indicated a mean length of stay of 1.77 days. For the non-summer period the average length of stay is estimated to be 1 day. Multiplying the average length of stay by the number of recreators yields 160,627 and 10,790 which are the total number of recreation days at the car counters during the summer and non-summer periods respectively.

The allocation of total recreation days between activities is made using the survey data presented in Table IV. The allocation is made separately for the summer and non-summer periods because the relative proportions of activities change across seasons. The picnicking data were not used because this activity is not being considered, and the shore and boat fishing data were combined. As seen in Table IV, fishing and camping dominates the summer season, and fishing dominates the non-summer activities.

These estimates for activity days are only for those persons who crossed car counters. Estimates of total Lake recreators are obtained by scaling the above estimates according to the proportions of recreators who crossed car counters. One objective of the boat survey was to estimate the proportion of recreators who crossed car counters. The results of this survey are depicted in Table VII for the summer and non-summer period. The percent of recreators crossing car counters is indicated in the right hand column and is based on a total sample size of 13,132. As indicated in this table, the large majority of recreators do not cross car counters.

The above car counter data do not include camping. Most of the camping

TABLE VII

SHORELINE CAR COUNTER COUNT 9/15/81 - 9/15/32

Activity	Crossed Counter	Did Not Cross Counter	Percent Crossing Counter
	Frequency - Summer		
Swimming	1,152	5,508	17.30
Boating	410	2,455	14.31
Fishing (Boat)	325	1,034	23.91
Fishing (Shore)	26	121	17.69
Total Fishing	351	1,155	23.31
Totals	1,913	9,118	17.34
	Frequency - Non-Summer		
Swimming	4	4	50.0
Boating	11	102	9.73
Fishing (Boat)	208	1,474	12.37
Fishing (Shore)	10	288	3.36
Total Fishing	218	1,762	11.01
Totals	233	1,868	19.09

on Flathead Lake occurs at public campgrounds such as state parks. The assumption made here is that all campers crossed car counters. Since car counters were placed at all state campgrounds, these campers should have been recorded. However, there are some private campgrounds on the Lake, and these camping days will not be estimated.

Campers often engage in multiple activities during a single day. That is, in addition to camping, campers may swim, fish or boat. The interdependence of activities cannot be estimated with the available survey data. The consequence of multiple activity days is that the allocation of total recreation days by activity understates participation in each activity. If participation in each activity were correctly estimated, then the total number of days would be over-estimated, because some days would have multiple counts. The main objective is to estimate total recreation participation and to place a monetary amount on this participation.

An estimate of total recreation participation at Flathead Lake during the summer of 1981 and following non-summer period is presented in Table VIII. Total recreation days by activity are estimated by taking total recreation days across the car counters for the summer (160,627) and non-summer (10,790) periods, multiplying by proportion of days for each activity (Table IV) and dividing by the proportion of cars crossing car counters (Table VII).

TABLE VIII

RECREATION PARTICIPATION OF FLATHEAD LAKE BY ACTIVITY FOR 1981

Activity		Summer	Non-Summer	Total
Fishing		218,442	71,002	289,444
Swimming		140,634	48	140,682
Camping		53,473	2,094	55,567
Boating		187,567	6,742	194,309
	Total	600,116	79,886	680,002

Section IV. A REGIONAL RECREATION MODEL

This section develops a regional recreation demand and benefits model that is used to evaluate a large number of sites in the Pacific Northwest. The region considered is the Pacific Northwest River Basin, which consists of Washington, Oregon, Idaho and Western Montana. Recreation demand and benefits are estimated for Flathead Lake and River system as a part of the simultaneous estimates for all other sites in the region. The model for the entire region and the input data base are the focus of this section. The following section is an application of the regional model to the Flathead area.

The essence of this regional model is that a gravity model is used to generate input data for a large number of travel-cost recreation demand curves. Total quantity (of recreation days) is estimated with the gravity model, and the value of recreation use is estimated as the area under the travel-cost demand curves. A 1980 regional household recreation survey is used to estimate the number of recreation trips by activity from each origin in the region. An attractiveness model is used to obtain preliminary estimates of the attractions of each site in the region. The distribution of trips between each origin and destination is estimated via a gravity model. The output of the gravity model is the number of visitor days received by each site in the region by activity and emanating from each origin in the region. These outputs are the basic input required to calculate a travel-cost demand schedule for each recreation site in the region.

This analysis of recreation behavior differs from existing studies by virtue of magnitude, with 195 recreation centroids defined over three and one-half states. This scale is considerably larger than those in the regional models of Burt and Brewer (1979), Cichetti, Fisher and Smith (1976), Cesario and Knetsch (1976) and Knetsch, Brown and Hansen (1976). The primary advantage of this size model is that any site within the region can be analyzed. Also, the influence of all potential substitute sites is most likely to be reflected in a larger model. The ability to analyze a large number of sites results from the use of household surveys to estimate recreation trips by origin and a gravity model to estimate the distribution of these trips.

Most recreation analyses focus on one activity or treat recreation as a composite homogeneous good, e.g., Stevens' (1966) estimate of the fishing benefits resulting from improved water quality. In contrast, this analysis considers four activities: camping, fishing, boating and swimming. A focus on one activity may be inadequate when several activities respond to water quality improvement. These four activities are not homogeneous; they differ in their response to site characteristics such as water quality, average travel distance and length of stay, and value per activity day. For these reasons, the above four activities are analyzed separately.

As a brief overview, the model consists of four integrated components: a trip production model, an attractiveness model, a trip distribution (gravity) model and a demand and valuation model. The trip production model is used to estimate the number of recreation days by activity which emanate from each population centroid in Washington, Oregon, Idaho, and Western Montana. The attractiveness model is used to estimate the attractiveness, or total quantity demanded of each recreation centroid in the region. Recreation days produced and attracted enter a gravity model where they affect the distribution of recreational travel. A gravity model estimates a trip interchange matrix, which, for each recreation centroid, is the number of activity days received from each origin. These outputs are used to estimate a travel-cost demand curve for each recreation destination and for each of the four activities considered. Recreation value is measured as the area under the demand curve and above the market price, which in this study is presumed to be zero.

A. Gravity Model Overview

The gravity model as applied to travel behavior is a trip distribution model which is used to estimate trip interchanges between all pairs of origins and destinations. Normally, the number of trips produced and received by each zone are exogenous variables. The endogenous variable is the allocation of these productions. The basic premise of the model is that the number of trips produced by origin i and attracted to destination j is directly proportional to 1) the total number of trips produced in i, 2) attracted to j, and 3) inversely proportional to a function of spatial separation between the zones.

The gravity model is ideally suited to estimate the distribution of recreation travel. However, the most stringent limitation of the model, for purposes of recreation analysis, is the requirement that attractions are exogenous. According to this assumption, the quantity of recreation use demanded at each site is known, and the gravity model solves for the allocation of this demand by origin. Previous versions of the model, including Sutherland (1982), are subject to this limitation. The gravity model is first developed in this section along traditional lines using exogenous attractions. In the latter part of this section the gravity model is extended to simultaneously estimate attractions. This extension results in a substantial improvement, both theoretically and empirically, in the regional recreation demand model.

Several specifications of the model have been put forth; the specification used here is one which is used widely in transportation analysis and was developed by the Bureau of Public Roads (1965). The equations are

(IV.1) $$T_{ij} = P_i \frac{A_j F_{ij}}{\sum_j A_j F_{ij}}$$

and the constraints

$$\sum_j T_{ij} = P_i \qquad \text{(IV.2)}$$

$$\sum_i T_{ij} = A_j, \qquad \text{(IV.3)}$$

where i refers to origin and j to destination. The symbols in (IV.1) are defined as

T_{ij} = number of activity days produced at i and attracted to j

P_i = number of activity days produced at i

A_j = number of activity days attracted to the jth recreation centroid

F_{ij} = a calibration term for interchange ij, which reflects the effect of distance.

Equation (IV.2) states that the estimated trip interchange matrix (T_{ij}) must imply that the total number of trips from origin i ($\sum_j T_{ij}$) is equal to the exogenous number of trips produced. In the calibration procedure used here and elsewhere, this constraint is satisfied automatically. According to (IV.3), the estimated trip distribution matrix, which estimates the number of trips terminating at each site, must also be consistent with exogenously estimated attractions.

The gravity model, as generally used, is a distribution model; it takes a given number of recreation activity days emanating from population centroids and distributes these days according to the relative attractiveness and spatial impedance between centroids. In the special case where site attendance data and trip production data are available, the gravity model is well suited to estimate allocation of these trips. If site attendance data are unavailable, they must be estimated by a demand model. Ideally, a demand model would include travel costs to all substitute sites and the relative attractiveness of all substitute sites. Such a demand model would be quite similar to the gravity model. In this study the gravity model is extended to include endogenous attractions; hence it becomes a demand and distribution model.

As noted by Ewing (1980), equation (IV.1) has two important properties. Adding destinations to the system or increasing the attractiveness of the existing destinations will increase the number of trips to that destination, but at the expense of alternative destinations. That is, the total number of trips is exogenous. Second, the model allocates trips by considering the substitutability between recreation centroids, a property particularly important for recreation analysis. The proportion of trips emanating from i with destination j is a function of the attractiveness and spatial impedance of destination j relative to that of alternative recreation centroids in the system. As reflected in the denominator of (IV.1), all sites in the region are considered as potential substitutes being analyzed. This property plus the definition of substitutes in terms of both travel distance and attractiveness make the gravity model appealing for a regional recreation analysis. Since the quantity of recreation demanded at each site depends on the same variables that are in the gravity model, it is important to incorporate this interdependence in the overall model.

When applied to transportation ptoblems, the dependent variable is trips, however the variable of interest in recreation studies is recreation days or activity days. In this study, the terms will be used synonymously and a distinction will be made only for trips of more than one day. Origins and destinations are often defined as zones or centroids. The term population centroid is used to define the origin zone and recreation centroid to define recreation zone. In each case, a centroid is a point but is used to represent origins and destinations of the neighboring area.

The rationale for using a gravity model is that the estimated trip interchange matrix (T_{ij}) serves as an input in estimating a large number of travel cost demand schedules. Each column vector in T_{ij} estimates the number of recreation activity occasions produced at origin i with a specific recreation destination. In this study j = 1,2,...195, so 195 demand curves can be estimated for each of the four activities considered. Since destinations can be added to the analysis, the model potentially can estimate a demand curve and recreation value for each activity and for any site in the region. The construction of the gravity model input data is explained in Section 2.

B. Gravity Model Input Variables

The three gravity model input variables are developed in this section. The spatial impedance variable (F_{ij}) is discussed first, followed by the trip production model (P_i) and the attractiveness model (A_j).

A necessary input to construct the F_{ij} terms is the impedance matrix (I_{ij}), which contains the minimum driving distance from each population centroid (internal and external to the region) to each recreation centroid in the three-state region. This matrix was estimated by first defining the population and recreation centroids of each county, and where appropriate, multirecreation or multipopulation centroids were used per county. There are a total of 129 counties in Washington, Oregon, Idaho, and Western Montans, but there are 141 internal population centroids and 195 recreation centroids. In this model the remainder of the United States and Canada is divided into 14 external zones, so there are a total of 155 population (origin) centroids. The population and recreation centroids are listed in Sutherland (1982). After each centroid was defined and located on a highway map, a network was constructed to show the distance between intersections along major roads. Possible routes from each population centroid to each recreation centroid were thereby identified. A computer program was used to solve for the minimum driving distance between each population and recreation centroid. The resulting travel distances constitute a 155 by 195 impedance matrix. Each column vector in this matrix denotes the minimum one-way mileage from each population centroid to a specific recreation centroid. The impedance matrix is an input in the gravity model, and the column vectors in the matrix will also be used as inputs in the travel cost demand curves.

The F_{ij} variable in (IV.1) reflects the influence of travel distance (or time) on the propensity to travel. This variable is estimated as the dependent variable in a trip length relative frequency distribution, which is also termed a decay curve.

The 1980 regional household survey included a question on the one-way travel distance in miles for each recreation trip. Since the sample size exceeds 3,000 and several persons in each household may have taken numerous trips, only a sub-sample of the sample results is used to estimate the decay curves. Every fifteeth questionnaire was sampled and the number of activity days by type and the corresponding one-way miles traveled were recorded.

Preliminary estimates using a Gamma distribution, a power function and an exponential function were unsuccessful. Using exponential smoothing, the estimated proportion of people traveling any distance is equal to the sum of the proportion of people traveling the previous x distances divided by x. After experimenting with x = 5, 10, and 15, it was decided to smooth over the previous 10 distance groups, where distance is also measured in 10 mile increments. The estimated decay curves using expenential smoothing are depicted in Figure 1. The trip length frequency distributions in Figure 1 show that recreationists who swim, fish and boat strongly prefer to travel short distances. In contrast, the camping decay curve is peaked, with most camping trips occurring between 50 and 100 miles.

The main use of these decay curves is to transform impedance values into the F_{ij} matrices. By substituting each impedance value into the four decay curves, an F_{ij} matrix is constructed for each activity. This matrix is one input in the gravity model, Equation (IV.1). The estimates in an F_{ij} matrix can be interpreted as the probability that a recreator residing in origin i will travel the distance from i to destination j.

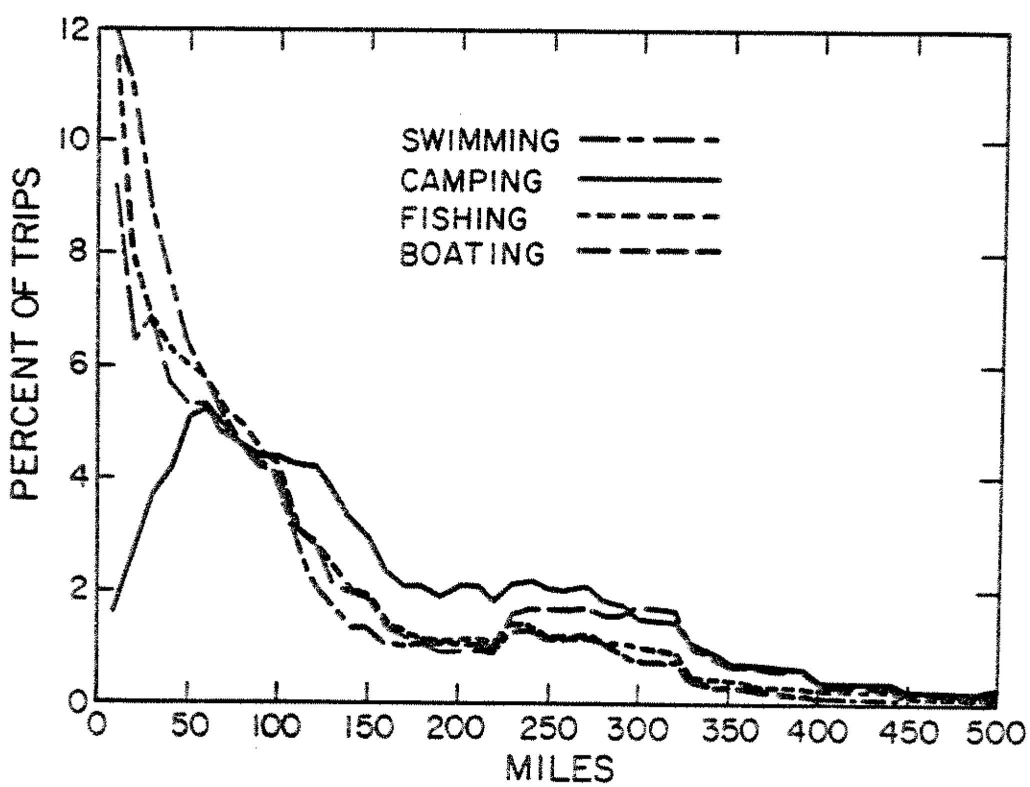

Figure 1

A household recreation survey was conducted in the fall of 1980 to obtain data to estimate recreation trips produced by origin by type of trip. A telephone survey was undertaken by the Survey Research Center at Oregon State University, specifically for use in this model. The recreation participation model developed here differs from those in the literature first by using the household as the sample unit and by focusing on recreation trips as a composite variable and then explaining the composition of a trip by activity. The conceptual rationale for focusing on the household is that recreation decisions may often be joint decisions where the entire family participates. The probable interdependent decision making within the family suggests that the household is a more appropriate unit for analysis than the individual. The statistical benefit of focusing on households is the increased probability that at least one member of the household participates in recreation.

By considering a composite of recreation activities, the probability that someone in the household participates is again increased. A zero response is obtained only when no one in the household participates in any of the four activities. The number of zero responses in most studies and the conventional two-step estimation procedure is no longer necessary.

More than one recreation activity is often undertaken during one recreation trip. For example, during a weekend camping trip, some family members may fish and boat while others swim, and some family members may enjoy each activity. The demand curve for recreating by a single activity may be different from one for the same activity where other activities also occur. The interdependence of recreation activities will be considered by analyzing recreation trips as a composite and then explaining the activity composition of these trips.

Consider first the possibility that the most appropriate recreation participation estimator is the sample mean of trips per household. The hypothesis that populations have the same participation rate can be tested by a one-way analysis of variance. The formal statistical hypothesis is that the mean number of trips per household is constant across subregions within the total region. The first test is whether the mean number of trips per household is constant across the three states. The sample means equal 5.5, 5.5, and 8.6 for Oregon, Idaho, and Washington, respectively, for summer trips, and 1.6, 1.3, and 2.9 trips per household for winter trips. The observed F statistics are 20.23 (summer) and 17.55 (winter), which reject the hypothesis of equal means across the three stages.

The second test is whether the mean number of trips per household is constant across counties for the 40 counties sampled. The observed F statistics are 3.67 (summer) and 2.90 (winter), which are larger than expected at the 95 percent level if the means were constant. The third hypothesis is that means are equal across counties, but where counties are grouped by state. Reporting the summer F values first and the winter values second, the F statistics are 2.42 and 2.90 for Oregon, 5.11 and 1.85 for Idaho, and 1.93 and 1.18 for Washington. Each of these F value suggests rejecting the hypothesis of equal means at the 95 percent level. However, some of the F values are close to their theoretical value, which is not true of the above two tests.

The implication of these tests is that recreation participation (in camping, fishing, boating, and swimming) differs across three of the states in the region and between counties within each state. The main source of this variation comes from Washington residents who recreate more on the average than Oregon and Idaho residents.

Since mean trips per household are apparently not constant across counties in the region, the non-random variation in household trips should be explained. The number of trips per household (summer plus winter) is postulated to be a linear function of demographic and recreation supply variables. The only demographic variables included in the model are household size and household income, because these are the only demographic data for which data were collected.

The relevant supply measure of recreation opportunities includes the necessary recreation facilities and the distance of these facilities from the population centroid. The recreation facilities used here are: number of camping units, boat ramps, linear designated beach feet, and river plus shoreline miles for camping, boating, swimming, and fishing, respectively. The recreation supply variables, defined as recreation accessibility, are estimated as a function of the availability of facilities, and the willingness to travel the necessary distance to these facilities. Let F_{ij} denote the probability of driving the distances from population centroid i to the jth recreation centroid. The recreation accessibility of each population centroid (RA_i) for one activity is estimated by summing recreation facilities (Fac_j) over all recreation centroids in the region weighted by the probability of driving the corresponding distances. That is,

(IV.4) $$RA_i = \sum_{j}^{195} F_{ij} \, Fac_j,$$

where $i = 1,2,\ldots 155$ and where RA_i measures the accessibility of recreation opportunities to the ith population centroid. Equation (IV.4) must be estimated separately for each of the four activities, because the friction factors (F_{ij}) and facilities are unique to each activity. Using (IV.4), recreation accessibility was estimated for each activity and for each population centroid in the region.

As a measure of the supply of recreation opportunities, recreation accessibility has some commendable properties. First, every recreation destination in the region is considered in this measure. Second, these opportunities are summed, but weighted by the probability of driving the necessary distance. Limitations of this measure are the data requirements to estimate it and that conjestion is ignored.

From the above defined variables, the trip production model is expressed as

$$T_i = (HS_i, Y_i, RA_c, RA_f, RA_b, RA_s, D_1, D_2) \tag{IV.5}$$

where the variables are defined as:

T_i = number of trips produced by household i

HS_i = number of people in household i

Y_i = personal income of family i

$Ra_{c,f,b,s}$ = recreation accessibility for camping, fishing, boating, and swimming.

D_1 = dummy variable = 1 if Oregon and 0 otherwise

D_2 = dummy variable = 1 if Idaho and 0 otherwise

The state dummy variables are included because the analysis of variance tests revealed recreation participation rates vary across states.

The number of households surveyed exceeded 3,000 which yielded more data than is necessary for regression analysis. Those respondents who failed to answer a question, particularly on family income, were deleted, as were one-half of the remaining responses. Using a sample size of 1545 households, a trip production model is estimated to be:

$$\begin{aligned} T_i = 5.71 &+ \underset{(4.35)}{0.983}\, HS_i + \underset{(3.84)}{0.879}\, Y_i + \underset{(0.14)}{0.0001}\, RA_s - \underset{(-2.55)}{0.014}\, RA_c + \underset{(0.14)}{0.0008}\, RA_f \\ &+ \underset{(2.01)}{0.346}\, RA_b - \underset{(-1.25)}{1.695}\, D_1 - \underset{(-2.83)}{3.345}\, D_2 \end{aligned} \tag{IV.6}$$

where t values are in parentheses and $R^2 = 0.053$. The encouraging results from equation (IV.6) are that household size and income have positive coefficients that are highly significant. Unfortunately, only one recreation accessibility variable (boating) is significant and of proper sign.

The main purpose of equation (IV.6) is to estimate the number of trips per household for each population centroid in the region. Since the model will be used for estimating purposes, it should not contain insignificant coefficients. After eliminating the insignificant variables, the model becomes

$$\text{(IV.7)} \quad T_i = 5.005 + \underset{(4.399)}{0.993\,HS_i} + \underset{(3.846)}{0.876\,Y_i} - \underset{(-4.709)}{4.084\,D_1} - \underset{(-3.865)}{3.053\,D_2}$$

where $R^2 = 0.049$, and where household size and income remain highly significant. The negative coefficients for the dummy variables are consistent with the analysis of variance result that participation rates differ across the three states.

The recreation accessibility variables do not appear in (IV.7) because they are not significant. Recreation facility variables are subject to serious measurement errors, which at least partially explains their estimated insignificance. An implication of the insignificance of the accessibility variables is that increasing recreation facilities will not causepeople to increase their participation, although they may redistribute their demand for recreation sites.

Equation (IV.7) is used to estimate the expected number of recreation trips produced by household for each county in the three-state region and Western Montana.[4] Census data for 1980 on household size by county and 1979 Department

[4] Total county trip data were transformed into total recreation days by first multiplying trips by the average length of stay. For Oregon, Idaho, and Washington, the sample survey estimates are: 2.439, 2.194, and 2.453 days per trip, respectively. The average size of a recreation party is estimated to be the mean household size, which is 2.60, 2.85, and 2.61 for Oregon, Idaho, and Washington according to the 1980 census. Total recreation days per county are estimated as the product of total trips, average length of stay, and number of persons per trip. For the three-state region, households average about 8.6 trips per year and, considering household size and length of stay, about 55.4 recreation activity days per year.

of Commerce county income data were substituted into (IV.7) to estimate trips per household by county. The number of households by county -- obtained from the 1980 census -- was multiplied by trips per household to estimate total trips per county.

The Oregon State University survey data was also used to allocate total recreation days by county to the four activities: camping, fishing, boating, and swimming. Treating each state separately, frequently distributions were constructed showing the proportion of days of participation in each activity (see Table B.1 in Appendix B). These proportions were then multiplied by total recreation days by county to estimate number of days by activity for each county. Estimates of activity days were also constructed for ten counties in Western Montana. Regional mean sample data were used to produce these estimates.

The gravity model also requires an estimate of the attractiveness of each recreation centroid. Attractions are postulated to be an exponential function of recreation facilities and the accessibility of the recreation centroid, which measures the likely demand on that centroid. Utilization rates at recreation sites tend to vary inversely with the distance to population centers. The responsiveness of attractions to changes in facilities should therefore be positively related to the nearness of these facilities to population centers. Furthermore, attractions should respond to increments in facilities at a diminishing rate, because demand cannot increase indefinitely in proportion to facilities. The attractiveness model is specified in exponential form to allow for the diminishing returns effect and the interaction between facilities and accessibility.

Accessibility of recreation centroids, called population accessibility, is a function of the number of trips produced by each population centroid and the likelihood that these trips will terminate at that recreation centroid. The accessibility of each recreation centroid is estimated by summing trips produced (P_i) by all population centroids weighted by the probability of driving the distance to the recreation centroid. That is, population accessibility for the jth centroid is

$$PA_j = \sum_{i}^{155} F_{ij} P_i \tag{IV.8}$$

where the F_{ij} values are obtained from the decay curves. Estimates from (IV.8) were constructed for each recreation centroid in the region and for each of the four activities being analyzed. Recreation accessibility data are one input in the recreation attractiveness model.

The attractiveness model also assumes that demand at a site is a positive function of the site characteristic. The facility variables used are camping units, river and shoreline miles, boat ramps and linear designated beach feet for camping, fishing, boating and swimming, respectively. U.S. Forest Service data on visitor days and facilities by ranger district were used with the accessibility data obtained from (IV.8) to estimate the attractiveness model. As seen in the first four rows in Table IX, the accessibility coefficients are not significant in all the equations. This insignificance is due partially to poor quality P_i data, because similar estimates based on older survey data showed this variable to be significant. The facility variables are overall significant and have positive signs as expected. The positive accessibility coefficients indicate that use for each activity is greatest for those sites located near large production centroids. Since the equations are in multiplicative form, a positive accessibility exponent implies that the responsiveness of use to facilities is positively related to the accessibility of a site. That is, for a given increment in facilities, use will be greatest for those sites which are

TABLE IX

REGRESSION ESTIMATES OF EXOGENOUS AND ENDOGENOUS ATTRACTIONS (in natural logs)

Equation Number	Activity	Intercept	Recreation Facility	Recreation Access	Coef. of Det. Sample Size
(IV.9)	Swimming	1.060 (0.943)	0.194 (2.902)	-0.216 (-0.721)	$R^2 = 0.18$ n = 42
(IV.10)	Camping	-0.396 (0.372)	0.631 (5.460)	0.466 (2.123)	$R^2 = 0.41$ n = 49
(IV.11)	Fishing	0.571 (0.270)	0.498 (1.356)	-0.097 (-0.336)	$R^2 = 0.04$ n = 49
(IV.12)	Boating	1.242 (0.698)	0.586 (3.363)	0.691 (1.394)	R = 0.25 n = 36
(IV.9')	Swimming	-4.052 (-2.309)	0.163 (2.585)	0.576 (2.487)	$R^2 = 0.29$ n = 42
(IV.10')	Camping	-2.763 (-2.315)	0.509 (4.781)	0.591 (3.955)	$R^2 = 0.52$ n = 49
(IV.11')	Fishing	-2.810 (-1.286)	0.598 (-1.697)	0.341 (1.875)	$R^2 = 0.11$ n = 49
(IV.12')	Boating	-9.716 (3.730)	0.621 (4.287)	1.408 (4.210)	R = 0.47 n = 36

Note: The numbers in parentheses are t values. The dependent variables are activity days for swimming, camping, fishing, and boating, respectively. The first independent variable is the facility variable which is linear designated beach feet (BF_j), camp sites (CS_j), acceptable river miles (RM_j), and boat ramps (BR_j). The second independent variable is accessibility for swimming, camping, fishing and boating, respectively.

most accessible. Facility and accessibility data for each recreation centroid were substituted into Equations (IV.9) -- (IV.12) to estimate relative attractiveness of each centroid in the region.

The three inputs in the gravity model, P_i, A_j, and F_{ij} have been estimated with a trip production model, a trip attractions model, (IV.9) -- (IV.12, and by transforming the impedance matrix with the decay curves. The output of the gravity model is a trip interchange matrix (T_{ij}) which gives the number of trips emanating from population centroid i with recreation centroid j as the destination.

The statistical estimates of the attractiveness model are unimpressive in terms of overall explanatory power and in the failure of the accessibility variable to be positive and significant. Recreation data are typically of low quality and the data used in the attractiveness model are no exception. In addition, there may be a specification problem with the attractiveness model. The gravity model has the desirable property of distributing trips according to the attractiveness of a recreation site relative to all substitute sites in the region, and according to effect of distance to the site (F_{ij}) relative to all sites in the region. The gravity model includes the effect of substitute sites in terms of relative travel distance (or travel time) and relative attractions. Incorporating this property into the attractiveness model would be highly desirable. Since one input for this extension results from calibrating the gravity model, a discussion of this calibration procedure is provided first.

C. Calibrating the Gravity Model

A trip interchange (T_{ij}) matrix is illustrated in Table X. A row depicts the number of trips received by each destination centroid emanating from a given origin. Similarly the columns depict the number of trips emanating from each population centroid with a given destination. Since the region is defined to be closed, the total number of trips produced must equal the total number of trips received, which in turn equals the total sum of trips in the trip interchange matrix.

Unfortunately, the best estimates of T_{ij} are not obtained simply by substituting the input data into the gravity model (IV.1) and solving. First, the estimated trip length (miles one way) frequency distribution obtained from using the estimated T_{ij} values and the impedance matrix typically would not correspond with the assumed known distributions, i.e., the decay curves. Secondly, the estimated number of trips received at each recreation centroid would not correspond with the attractiveness input data. That is, the sum of the column vectors in Table 3 will not equal A_j.

TABLE X

TRIP INTERCHANGE MATRIX

	Trip Interchange Matrix (T_{ij})						Trip Productions P_i
	1	2	.	.	.	m	
1	T_{11}	T_{12}	.	.	.	T_{1m}	$\sum_j T_{1j} = P_1$
2	T_{21}	T_{22}	.	.	.	T_{2m}	$\sum_j T_{2j} = P_2$
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
n	T_{n1}	T_{n2}	.	.	.	T_{nm}	$\sum_j T_{nj} = P_m$
Trip Attractions A_j	$\sum_i T_{i1} = A_1$	$\sum_i T_{i2} = A_2$	.	.	.	$\sum T_{im}$	$\sum^m A_j = \sum^n P_i = \sum_{ij}\sum T_{ij}$

The gravity model is therefore calibrated with an iterative technique where a new trip interchange matrix (T_{ij}) is estimated by each iteration. The elements of the new T_{ij} matrix are used to estimate a trip length frequency distribution and are summed vertically to estimate A_j values and if a significant discrepancy exists, the iterative process continues. The gravity model is calibrated to produce a T_{ij} matrix which yields a decay curve corresponding to the exogenous decay curve and estimated attractions which correspond to exogenous attractions. When the estimated and observed A_j values and decay curves are satisfactorily close, as judged by some predefined criteria, the iterations conclude.

To define this calibration technique more precisely, recall that the conventional gravity model includes the constraint (IV.2), which in terms of Table X is

$$\sum_i T_{ij} = A_j, \text{ for each } j. \tag{IV.13}$$

Each iteration of the gravity model necessarily satisfies the production constraint, Equation (IV.2), because the ratio component of (IV.1) sums to one. However, (IV.13) is not generally satisfied by the first or even second iteration. The calibration technique brings the estimated and observed trip length distributions together and also satisfies (IV.13). In each iteration, attractions are multiplied by the coefficient b^c which reflects the discrepancy between A_j and $\sum_i T_{ij}$ estimated in the previous iteration. This adjustment coefficient is obtained from

$$b^c = b^{c-1} \frac{A_j^{c-1}}{\sum_i T_{ij}^{c-1}} \tag{IV.14}$$

where c designates the number of iteration. The attractions for each iteration after the first iteration are estimated by multiplying the previous attractions by the adjustment coefficient obtained from (IV.14). This procedure results in (IV.13) being approximately satisfied.

According to this conventional calibration technique, the number of trips received by each recreation centroid is estimated by the attractiveness model, equations (IV.9) - (IV.12), on the basis of facilities at the site and accessibility of the site. The attractiveness model, as defined this far, does not consider the effect of substitute sites as does the gravity model estimate total trips received.

A procedure similar to (IV.14) is used to adjust the friction factors F_{ij}. The travel distance factors used in the cth iteration (F_{ij}^{c}) are equal to the product of the factors used in the previous iteration (F_{ij}^{c-1}) and the ratio of observed to calibrated trips which occur from i to j. That is,

(IV.15) $$F_{ij}^{c} = F_{ij}^{c-1} \frac{OD}{GM}$$

where the numerator is the percent of trips implied by the decay curves and GM is the percent of trips for the same distance which is predicted from the gravity model. The gravity model is calibrated using an iterative approach as defined by (IV.14) and (IV.15). Three iterations are generally required for the trip interchange matrix (T_{ij}) to approximately satisfy the attractions constraint (IV.3) and to produce a decay curve which closely corresponds with the observed decay curve.

The empirical estimates of the attractiveness model in Table IX are disappointing, particularly because the accessibility coefficients failed to be significantly positive as expected. Recall that accessibility is estimated as the sum of trips produced weighted by the F_{ij} values, which are probabilities of driving various distances. The F_{ij} values are estimated from decay curves, which in turn are estimated with regionwide trip length data. The decay curves are probably an accurate representation of recreation travel overall, but they are not necessarily accurate for any individual site. If a recreation site is close to a large urban area most trips will have short travel distances, and the tail of the decay curve will terminate close to the origin. Alternatively, if all origins to a site are several miles away, the appropriate decay curve must reflect a large area under these corresponding distances.

The attractiveness model estimated above presumed that a decay curve estimated with regionwide data would be applicable to each site. A preferred alternative is to estimate a decay curve for each site which reflects the influence of substitute sites.

The gravity model produces a T_{ij} matrix (Table X), but it also estimates an F_{ij} matrix via the iterative procedure. An F_{ij} matrix is a gravity model input variable and it is based on a single regional decay curve. The algorithm for computing T_{ij} is iterative and it continues to adjust the F_{ij} values until estimated attractions balance with A_j and the decay curve implicit in the T_{ij} matrix balances with the regional decay curve.

The iterative calibration process results in a new F_{ij} matrix in each iteration. Implicit in this matrix is a decay curve which is unique to each site. The final iteration produces an F_{ij} matrix where each column vector implicitly contains a decay curve unique to the corresponding destination. Since these F_{ij} values are computed by the gravity model, they reflect the influence of the independent variables in the gravity model.

The gravity model was estimated using the input variables defined above, including the attractiveness variables predicted from equations (IV.9) - (IV.12) in Table IX. From this version of the gravity model, the estimated F_{ij} values were obtained. These values are used to reestimate the recreation accessibility measure equation (IV.8) and then to reestimate the attractiveness model.

Empirical estimate of the second version of the attractiveness model appear as Equations (IV.9') - (IV.12') in Table IX. The explanatory power of the model, as measured by R^2, shows an improvement in each of the four equations over the previous estimates. Each of the accessibility coefficients is positive and 3 of the 4 are significant at the 1 percent level. Overall, on empirical grounds, this two-stage procedure for estimating the attractiveness model results in a dramatic improvement in the model. On theoretical grounds, the model is also improved because the same variables which determine the distribution of recreation travel also influence total demand at each site. In addition to being a distribution model, the gravity model is being used to estimate total demand.

The gravity model as estimated in this study produces two outputs necessary to estimate demand and benefits for recreation sites. First, quantity demanded is estimated for each centroid and for each of the four activities. For each recreation centroid, the gravity model also estimates the number of trips received from each origin. These data are transformed into visit rates and are a critical output in estimating travel-cost demand curves. Estimating a gravity model requires constructing an impedance matrix, which reflects the minimum travel distance from each origin (population centroid) to each destination (recreation centroid) in the region. These minimum travel distances, when multiplied by travel cost per mile yield travel cost estimates which are necessary to estimate recreation demand curves.

D. Estimating An Outdoor Recreation Demand Curve

In this study, travel-cost demand curves are estimated for each of four activities (fishing, swimming, camping and boating) and for a large number of sites, which are termed recreation centroids. A travel-cost demand schedule is now developed, but the notation is simplified by assuming one activity and one recreation centroid. Let T_i be the annual number of visitor days emanating from the ith population centroid and recreating at the site being analyzed, and let N_i by the population of the ith population centroid. Using C_i for the travel cost per person per visitor day from the ith zone, the equation

$$T_i/N_i = f(C_i) \tag{IV.16}$$

relates visit rates to travel costs. Equation (IV.16) is the general form of what is frequently termed the demand curve for the recreation experience, and it is often referred to as a per capita demand curve or visit rate schedule. The regression estimate of this equation is used to generate a site demand curve by first multiplying the equation by the population of the ith zone (N_i) to obtain

$$\hat{T}_i = f(C_i)N_i,$$

then summing all origins to obtain

$$\sum_i T_i = \sum_i (C_i)N_i, \tag{IV.17}$$

which yields an estimate of total visitor days as a function of total travel costs.

The essence of the TCM is that a site demand curve is inferred from the empirical relationship of visit rates by origin to corresponding travel costs (equation (IV.16)). Although travel costs are a transaction cost not a market price, they are treated as an implicit market price. The response of total recreation days to hypothetical prices is obtained by assuming that recreationists would respond to prices (entrance fees), just as they respond to the same change in travel costs. To estimate total visitor days as a function of increased travel costs or market prices, P is inserted in (IV.17) to obtain

$$\sum_i \hat{T} = \sum_i f(C_i + P)N_i. \tag{IV.18}$$

The prices for a site demand curve may be selected somewhat arbitrarily but should begin at zero and cover the full range of the demand curve. The quantity of visitor days demanded at each price is obtained from (IV.18) by letting each price equal P and solving for the corresponding quantity (T_i). A recreation site demand curve can then be estimated from these price-quantity observations. The site demand curve is usually estimated as a regression equation obtained from the price-quantity points. The final step is to estimate consumers' surplus, which is typically the integral of the estimated demand equation.

The focus of this study is on total quantity demanded at a zero price and on consumers' surplus, but not on the site demand curve _per se_. Furthermore, using regression analysis to estimate a site demand curve raises the issue of the proper functional form. Also, a regression estimate may be highly sensitive to the choice of hypothetical prices substituted in (IV.18). Since a site demand curve is unnecessary and regression analysis introduces some potential problems, an alternative procedure is developed.

Using a semilog specification, equation (IV.16) becomes

$$\ln(T_i/N_i) = \alpha + \beta C_i + \varepsilon_i. \tag{IV.19}$$

Taking antilogs of the regression estimate of (IV.19), multiplying by N_i and summing yields

$$\sum_i \hat{T}_i = \sum N_i e^{\hat{\alpha} + \hat{\beta}(C_i + \Delta P)}. \tag{IV. 20}$$

The price increments used here are \$1 from \$0 to \$4, \$2 from \$4 to \$12, \$4 from \$12 to \$76, or until a successive price increment increase consumers' surplus by less than one percent. Initially, one dollar price increments were used from \$0 to \$76, but experimentation showed that most of the consumers' surplus occurs at relatively low prices. Also, extensive computer time is required to perform the large number of calculations required for 780 (195 x 4) first-stage demand curves. For these two reasons, larger price increments were used as higher prices.

The hypothetical prices and the quantities generated from (IV.20) can be used to estimate recreation demand and value.[5] In lieu of estimating the site demand curve, consumers' surplus is estimated directly by applying Bode's Rule to the price-quantity data. Bode's Rule is an algorithm for integrating a fourth degree polynomial which fits five points equally spaced on the horizontal axis. Suppose that we are given five such points x_i, where $i = 0, \ldots 4$. Bode's rule approximates

$$\int_{x_o}^{x_4} f(x)\ dx$$

by fitting a fourth degree polynomial through the five points $(x_i, f(x_i))$. Bode's Rule is

$$\int_{x_o}^{x_4} f(x)\ dx = \frac{2h}{45}\left(7f_o + 32f_1 + 12f_2 + 32f_3 + 7f_4\right) + E$$

$$\text{where } E = \frac{8f^6\ \gamma\ h^7}{945},\quad x_o < \gamma < x_4$$

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[5] The approach here follows Clawson's original two-step method of estimating a visit rate schedule and using it to generate a site demand schedule, except that the integral of the site demand schedule is estimated without actually estimating that schedule. An alternative and simpler approach would be to integrate the first-state curve directly.

but the remainder E is set equal to zero. The h term is the interval, which is the price increment used in equation (IV.20). Bode's Rule is given in Davis and Robinowitz (1967, p. 30) and in Abramowitz and Stegun (1964, p. 886).

The use of Bode's Rule is illustrated by Figure 7. The first series of five equally spaced points is the prices from \$0 to \$4 in increments of \$1. The corresponding quantities are obtained from equation (IV.20). A fourth degree polynomial is connected to these five points and Bode's Rule is used to measure the area under this segment of the demand curve. The next series of five equally spaced points includes the price-quantity observations where prices ranged from \$4 to \$12 in \$2 increments. Bode's Rule is again applied to estimate the consumer surplus corresponding to this segment of the demand curve. The process continues until the last application of the algorithm increases consumer surplus by less than one percent of the total.

Section V. DEMAND AND VALUE ESTIMATES FROM A REGIONAL MODEL

The regional recreation model developed in the previous section is applied to Flathead Lake and River system to estimate total annual use by activity and the recreation value of this use. Applying the model to the Flathead region requires extending it to include Western Montana, because a multitude of origins and substitute sites (destinations) need to be included. The extension of the model is explained first, followed by the demand and benefits estimates for the Flathead region.

A. Data Base For Western Montana

The origin zones in the regional model include each county in Washington, Oregon and Idaho, several external zones, and various counties in Western Montana. The counties in Western Montana included in the model are those near the Flathead area and those containing relatively large population centers such as Helena and Butte. Other counties in Western Montana containing small populations were aggregated with the more populated counties. A list of the population centroids in Western Montana and their corresponding 1980 populations appears in Table XI. These population centroids were selected on the basis of their likelihood of sending recreators to the Flathead area.

The recreation centroids for Western Montana include those of the study area plus a representation of substitute sites. Flathead Lake is denoted by two recreation centroids, one on the West side of the Lake and one on the East side of the Lake. These centroids are 31 and 33 miles from Kalispell and each is 18 miles from Polson. The centroid on the North Fork of the Flathead River is 35 miles north of Columbia Falls. The centroid on the Middle Fork of the Flathead River is also 35 miles from Columbia Falls. These four destinations were selected to best represent the average travel distance to the study area.

TABLE XI

ORIGIN ZONES FOR WESTERN MONTANA AND EXTERNAL ZONES

Population Centroid Number	County	Population Centroid	Population
120.0	Cascade	Great Falls	89,367
121.0	Flathead	Kalispell	41,462
122.0	Gallatin	Bozeman	67,414
123.0	Flathead	Whitefish	10,000
124.0	Lake	Polson	19,098
125.0	Lewis and Clark	Helena	49,992
126.0	Lincoln	Libby	17,731
127.0	Missoula	Missoula	79,091
128.0	Silver Bow	Butte	95,067

Notes: The population estimates for Western Montana counties include neighboring counties, for which no population centroid is used. For instance, Missoula includes Mineral and Granite; Butte includes Silver Bow, Deer Lodge, and Powell; and Jefferson includes Beaver head and Ravalli counties. Population estimates for all United States counties and states are preliminary estimates from the 1980 census, U.S. Department of Commerce, Bureau of Census, 1980 Census of Population and Housing (by state), 1981.

The mainstem of the Flathead river, which extends 55.3 miles north of the Lake, is considerea here as part of Flathead Lake.

The closest neighboring substitutes for the study area are the reservoir at Hungry Horse Dam and Whitefish Lake, which is about 18 miles north of Kalispell. Somewhat further are McGregor Lake, Lake Koocanusa and Lake Alva. These lakes are by themselves substitutes for the study area, but they are also used to represent all the water-based recreation opportunities in their area. The remaining recreation centroids are defined arbitrarily to be about 50 miles from the corresponding population centroids. These destinations are used to reflect the recreation opportunities in the proximity of those population centers that send visitors to the Flathead area. The recreation centroids included to reflect the study area and neighboring substitutes are listed on Table XII.

TABLE XII

RECREATION CENTROIDS BY NAME AND BY COUNTY

Recreation Centroid Number	County	Recreation Centroid
120.0	Lake	Flathead Lake (1)[1]
120.1	Lake	Flathead Lake (2)
121.0	Flathead	Flathead River (1) North Fork
121.1	Flathead	Flathead River (2) Middle Fork
121.2	Flathead	Hungry Horse Dam
121.3	Flathead	Whitefish Lake
121.4	Flathead	McGregor Lake
125.0	Lincoln	Lake Koocanusa
126.0	Missoula	Lake Alva
126.1	Missoula	Missoula Rec.
127.0	Canada[2]	Calgary Rec.[3]
127.1	Canada[2]	Cranbrook Rec.
129.0	Deer Lodge	Butte Rec.
130.0	Meagher	Helena Rec.
131.0	Cascade	Great Falls Rec.
132.0	Park	Bozeman Rec.

[1] The centroids on Flathead Lake include the mainstem (55.3 miles) of the Flathead River.

[2] These two recreation centroids are in Canada.

[3] The recreation centroids defined by Rec. reflect a proxy for the composite recreation sites close to a particular population center.

After the population and recreation centroids were defined, the regional highway network was extended to include these centroids. The highway network defines alternative routes from each origin to each destination. Minimum distances were estimated using a computer program, and the result is an expanded impedance matrix that denotes the minimum travel distance from each origin in the region to each destination in the region. The impedance matrix is used in calculating travel cost demand curves and in calibrating the gravity model.

Two important inputs in the model are trips, or recreation activity days, produced by origin, and recreation facilities at the recreation centroids. Estimates of recreation activity days for the Montana population centroids are presented in Table XIII. The estimation procedure is explained in the previous section, but basically, it uses equations developed with 1980 household survey data for Washington, Oregon and Idaho, and Montana demographic data. By comparing the activity occasion estimates in Table XIII with the population estimates in Table XI, it appears that Flathead county residents fish an average of 5.19 days per year.

TABLE XIII

RECREATION TRIPS PRODUCED BY ORIGIN AND BY ACTIVITY, 1980

Recreation Centroid Number	Western Montana Activity Occasions (in 00)				
	County	Swimming	Camping	Fishing	Boating
120.0	Cascade	3,591	4,948	3,798	2,439
121.0	Flathead	2,317	3,192	2,450	1,574
122.0	Gallatin	1,729	2,382	1,829	1,175
123.0	Jefferson	261	359	276	177
124.0	Lake	761	1,047	804	516
125.0	Lewis and Clark	2,020	2,780	2,130	1,370
126.0	Lincoln	731	1,008	774	497
127.0	Missoula	3,702	5,101	3,916	2,515
128.0	Silver Bow	3,876	5,341	4,100	2,633

The recreation facility data for the Montana recreation centroids is presented in Table XIV. Data for the four Flathead centroids was obtained from personel of the Montana, Fish, Wildlife and Parks. River and shoreline miles data for the region was estimated with a planimeter. Camping and boating data were obtained primarily from 1978 Montana Statewide Comprehensive Outdoor Recreation Plan (SCORP), Volume 2, Outdoor Recreation Inventory. Montana Fish, Wildlife and Parks officials were consulted in an effort to obtain the best possible data. The Montana Recreation Guide, which is a map of Montana depicting the recreation area, was also used, particularly to identify swimming beaches.

TABLE XIV

RECREATION FACILITY VARIABLES

	County	Campsites	Beach Feet	Boat Ramps	River Miles
120.0	Lake/Flathead	48	1100	7	67
120.1	Lake/Flathead	96	1100	8	67
121.0	Flathead	1	1	4	58
121.1	Flathead	1	1	3	91
121.2	Flathead	175	100	7	72
121.3	Flathead	10	600	4	16
121.4	Flathead	20	300	4	120
125.0	Lincoln	30	900	3	50
126.0	Missoula	40	300	3	50
127.0	Canada[1]	500	350	4	100
128.0	Canada[1]	500	3300	4	100
126.1	Missoula	480	350	13	70
129.0	Deer Lodge	876	4200	19	50
130.0	Meagher	482	4500	9	64
131.0	Cascade	159	900	4	40
132.0	Park	750	900	14	120

[1] These recreation centroids are near Calgary and Cranbrook, respectively.

B. Recreation Demand and Value Estimates

The regional model presents numerous outputs for each site, such as trips by origin and first-stage demand curves, but consumers' surplus is the most important estimate. The operation of the model can be conveyed further by explaining several of the model outputs.

The output of the gravity model is a T_{ij} matrix which, in the regional model, is an input in the travel cost demand curves. The number of trips by origin is however an interesting piece of information. Using the east side of Flathead Lake as the destination, the relative frequency of trips by origin and by activity is presented in Table XV. These estimates can be compared to

TABLE XV

RELATIVE REQUENCY ESTIMATES OF TRIPS BY ORIGIN
ACCORDING TO ON-SITE SURVEY AND REGIONAL MODEL

		Survey	Regional Model			
		All Activities	Swimming	Camping	Fishing	Boating
Cranbrook	1	.003	.004	.002	.002	.010
Calgary	2	.015	.003	.007	.002	.030
Canada	3	.014	.007	.004	.004	.019
Lake Co.	4	.187	.138	.066	.150	.084
Flathead Co.	5	.406	.222	.140	.225	.157
Missoula	6	.149	.362	.186	.063	.231
Helena	7	.007	.031	.048	.025	.012
Great Falls	8	.012	.032	.066	.022	.054
Bozeman	9	.001	.014	.030	.009	.024
Butte	10	.007	.075	.014	.063	.093
Anaconda[1]	11	.000	--	--	--	--
Montana	12	.064	.018	.014	.020	.001
Outside Montana	13	.133	.113	.423	.435	.285
Outside U.S.	14	.001	--	--	--	--

Note: 1. The regional model does not include Anaconda and Outside the U.S. as origin zones. The on-site survey data reflects the summer period only.

those of the on-site survey.

The main pattern to emerge from both the on-site survey and the regional model is that most recreationists came from Flathead and Lake counties (these two counties border the Lake) and from Missoula county, which is just south of Lake county, and has a major population center. The larger cities in Montana, such as Butte, Bozeman, Helena and Great Falls, that are over 150 miles from the study area, account for relatively few visitors. The three Canadian centroids, which represent all of Canada, account for only about 3 percent of the recreators at Flathead Lake. A substantial share of the visitors come from outside Montana, but the main demand for the Lake is from nearby residences.

Comparing the regional model estimates to those of the on-site survey reveals a similar pattern but differences for several origins. In part, these differences are due to different definitions of the origin zones. In the on-site survey respondents were counted as residing in a city only if they resided in that city. In the regional model, a city reflects the population center of a county or of several counties. The regional model should therefore estimate a higher proportion of trips from the major cities in Montana than would the on-site survey and a lower proportion of trips from the remainder of Montana. An examination of the estimates in Table XV shows this relationship to be the case.

An important input in estimating travel cost demand curves is the operating cost per vehicle on a per day, per mile, and per person basis. The estimates used in the regional model are 9.07 cents per mile for fishing, swimming and boating, and half this amount for camping. The on-site Lake survey produced data that can yield a more accurate travel cost estimate for recreators at Flathead Lake. The regional model assumes 3.147 persons per vehicle and an operating cost of 12.2 cents per vehicle mile. The average fuel efficiency of the existing passenger car fleet in 1980 was 15.15 miles per gallon.

The average fuel efficiency of vehicles which visited Flathead Lake was 16.686 MPG, which is about 10 percent higher than the national average. The mean number of persons per vehicle is 2.69, according to the on-site Lake survey. The marginal cost of operating an intermediate car in 1981 was 6.6 cents per mile for gas and oil and 5.6 cents for maintenence, accessories, parts, and repair. The gas and oil cost is reduced to 6.1 cents per mile to reflect the better than average fuel efficiency of vehicles traveling to Flathead Lake.

Travel cost is estimated as 11.7 cents per mile and is doubled to reflect round trip travel. The result, 23.4¢ per mile is divided by 2.69 persons per vehicle to obtain 8.70 cents per mile. This number is used for boating, swimming, and fishing trips, but is divided by 2 for camping trips, which are assumed to be 2 day trips.

The above procedure for calculating travel cost is recommended by the Water Resources Council in its Procedures for Evaluation of NED Benefits (1979). The Council also recommends including the value of travel time in travel cost. On the basis of an Oregon State University household survey conducted in the Northwest, the willingness to pay to decrease travel time for most recreators is zero. Consequently travel costs are estimated here as marginal vehicle operating costs.

Travel-cost demand and valuation estimates for Flathead River and Lake are obtained from the regional model, beginning with the attractiveness model. The facilities and accessibility data for each site in the region by activity is substituted into the attractiveness equations (Table IX) to estimate relative attractions of each site in the region. Relative attractions are then scaled so that total trips produced equals total trips received in the region ($\sum_i P_i = \sum_j Aj$). These data are presented for the four recreation centroids defining the study region in Table XVI.

The estimates under the column denoted as SumTi reflect the number of recreation days at that centroid. The T_i vector is used along with population of each origin (N_i) and travel costs to construct a first-stage demand curve. The regression estimates of these demand curves for each activity and for each site are presented in Table XVI. The recreation (first-stage) demand curves presented here are part of system of demand curves for 195 recreation centroids in the three and one-half state region. The coefficients of determination (R^2) indicate that the model fits the data quite well; and the results for the Flathead area are typical of the entire region.

The last two columns in Table XVI are ECOVAL, which is economic value

TABLE XVI

REGIONAL MODEL OUTPUTS FOR FLATHEAD LAKE AND RIVER

Destination	Facility	Access	$SumT_i$	BO	B1	R2	ECOVAL	ECOVAL / $SumT_i$
			SWIMMING					
Lake, East	1,100	79,086	73,756	9.12	-.230	.872	354,240	4.80
Lake, West	1,100	79,310	74,106	9.10	-.230	.871	357,748	4.83
River, North	1	36,091	6,135	7.70	-.235	.873	32,628	5.32
River, Middle	1	42,739	7,928	7.75	-.233	.872	42,775	5.40
			CAMPING					
Lake, East	48	201,426	51,121	9.32	-.399	.794	303,120	5.93
Lake, West	96	202,602	73,552	9.66	-.389	.791	435,328	5.91
River, North	1	129,675	3,264	7.26	-.408	.799	16,897	5.18
River, Middle	1	146,178	3,923	7.24	-.403	.794	20,731	5.28
			FISHING					
Lake, East	67	72,438	87,748	9.12	-.216	.859	430,778	4.91
Lake, West	67	72,535	87,989	9.10	-.216	.857	432,992	4.92
River, North	91	28,523	25,709	8.87	-.213	.835	152,634	5.94
River, Middle	58	33,850	30,209	8.83	-.212	.835	178,923	5.92
			BOATING					
Lake, East	7	90,152	13,083	8.06	-.212	.799	151,020	11.54
Lake, West	8	90,572	14,372	8.13	-.211	.797	165,774	11.53
River, North	4	58,372	2,913	7.46	-.219	.795	32,477	11.15
River, Middle	3	64,759	3,136	7.31	-.216	.791	35,483	11.31

Notes: Facility and Access are independent variables in the attractions model. BO and B1 are the intercept and slope coefficients of a regression estimate of a first-stage demand curve. R^2 is the coefficient of determination of this regression estimate. ECOVAL is total consumers' surplus, and ECOVAL/$SumT_i$ is consumers' surpus per trip.

measured as consumers' surplus and ECOVAL/SumTi, which is consumers' surplus per trip. Most of the value per day estimates are in the $4 to $6 area, with boating being over $11.[6] A comparison of these estimates with those of other sites in the three-and-a-half state region indicates that the values for the study area are typical of the entire region. All the estimates are higher than I obtained in previous versions of the regional model. This increase in value is attributed to increased travel costs (due to gasoline prices) and a revised estimate of persons per vehicle.

Estimates in Table 16 include both value per trip and number of trips. The on-site survey resulted in a total demand estimate, and the mail survey resulted in a value per visit estimate. Some of the demand estimates from the regional model are similar to the survey estimates, but some estimates are very different. The model estimates fishing days on the Lake to be 172,655, whereas the survey estimate is 289,444. The facility variable for fishing is shoreline miles, which understates the availability of fishing opportunities on major lakes. In general, the on-site survey estimates of demand are probably more reliable than the model estimates, and hence the survey estimates will be used.

The model estimates of willingness to pay are about $4 to $6 with boating being over $11. In the mail survey, respondents reported a (sample mean) willingness to pay to be $7.35 per visit. Using visitor days by activity as weights, the weighted average willingness to pay according to the regional model is $6.59 per day. The consumer surplus estimates from the regional model will be used here, but it is reassuring to obtain similar estimates.

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[6] There is not an obvious explanation for the relatively high consumers' surplus estimate for boating. Consumers' surplus estimates for boating showed wide variations across the region. Eleven dollars is above the average for all sites, but not exceedingly so.

[7] Using the same Lake survey data but a different methodology, Graham and Fredenberg (1982) estimate total Lake fishing days to be 168,792 days.

Recreation demand and value estimates of Flathead Lake and River system are presented in Table XVII. As mentioned above, the visitor day estimates are obtained from the on-site survey and the value per day estimates obtained from

TABLE XVII

RECREATION DEMAND AND VALUE ESTIMATES FOR FLATHEAD RIVER AND LAKE

Activity	Visitor Days	Value Per Trip	Total Value
Flathead Lake			
Swimming	140,682	$ 4.81	$ 676,680
Boating	194,309	11.53	2,240,383
Fishing	289,444	4.91	1,421,170
Camping	55,567	5.92	328,957
	680,002		$4,667,190
Flathead River			
Fishing* (N.F.)	9,485	5.94	$ 56,341
Fishing (M.F.)	8,040	5.92	47,597
Fishing (M.S.)	35,940	5.93	213,124
Boating (North and Middle Forks)	6,221	11.23	69,861
	59,686		386,924
Grand Total	739,688		$5,054,114

*The abbreviations N.F., M.F., and M.S. refer to the North Fork, Middle Fork and Mainstem of the Flathead River respectively. The North Fork estimate reflects the summer period only. The Middle Fork estimate represents the September 12 through November 30 period, which is the Kokanee snagging period.

the regional model. In sum, there were a total of 739,688 annual visitor days in the study beginning May 15, 1981 who would be willing to pay a total of $5,054,114 to recreate on Flathead River and Lake.

Section VI: THE PRESERVATION VALUE OF WATER QUALITY[8]

The environmental economics literature identifies several possibilities of willingness to pay for the preservation of public nonmarket aspects of environmental quality that are distinct from the expected consumer surplus of recreation use. These preservation benefits include option, bequest, and existence demands as outlined by Weisbrod (1964) and Krutilla (1967). Option value is defined as the willingness to pay to avoid irreversible loss of the opportunity for future access to natural environments for recreation use. Bequest value is defined as willingness to pay for the satisfaction derived from endowing future generations with a natural environment. Existence value is the willingness to pay for the knowledge that a natural environment is preserved even though no recreation use is contemplated. Unfortunately, past studies of these values contain an inherent bias in that they estimate average preservation values for the population of a city, river basin or state without reference to the effect of distance from the study site. Estimates of the preservation value of water quality may be sensitive to the boundary definition employed. Some individuals with positive preservation values are not considered when too small a boundary is placed on the geographic extent of influence. Similarly, aggregate willingness to pay estimates are biased upwards if the sample estimate is extrapolated over to large a region.

The magnitude and direction of the effect of distance on preservation values is hypothesized to be a critical determinant of willingness to pay that has not received adequate consideration in the literature. The first stage of the travel-cost approach to estimation of recreation demand is based on the

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[8] This section was co-authored with Richard Walsh, Department of Economics, Colorado State University. The section is currently in the form of a paper being reviewed for publication.

proposition that visit rates from various origins are a decreasing function of distance. The consumer surplus of recreation use also declines with distance in the second stage of the travel cost approach. This inverse relationship between recreation use value and distance also may characterize willingness to pay for nonuse preservation values. For as nearness to a site increases the probability of recreation use, the enhanced knowledge and appreciation gained may translate into higher nonuse preservation demands. Distance is expected to have a negative effect on the nonuse preservation value of water quality at recreation sites such as the Flathead Lake and River which are known and visited primarily by a regional population, and possibly neutral or even positive effect on the preservation value of natural wonders such as Crater Lake, Niagara Falls, or the geysers at Yellowstone National Park which are known and visited by a national or international clientel.[9]

The contingent valuation approach is applied here because it is the only known method to value the preservation value of environmental quality before degradation occurs. To wait until after degradation of water quality by coal mining would be an unnecessarily costly form of experimentation (Brookshire and Crocker, 1979). The approach relies on the stated intentions of a cross-section of the hypothetical changes. The value reported is assumed to correspond to the point of indifference between having the amount of income stated or the environmental amenity. Because individuals cannot make water quality adjustments themselves, the measure of willingness to pay is a Hicksian compensating surpus value.

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[9] For example, Schulze, Brookshire and Thayer (1981) reported that distance from the Grand Canyon had no significant relationship to willingness to pay for preservation of its visual air quality. People in Chicago reported values fully as high as those living closer in Albuquerque, Denver, and Los Angeles. Moreover, on the average those who had never visited the Grand Canyon valued its visual quality as highly as those who had, or about $86 per household annually.

This study used an innovative procedure to estimate the preservation value of water quality. To begin with, the study followed the normal procedure for estimating the maximum total amount that households would be willing to pay annually to protect water quality in Flathead Lake and River (similar to Gramlich, 1977). In other words, each respondent made a single budget allocation decision based on total annual benefits received. The innovation was to ask each respondent to allocate this amount among the four categories of value: recreation use, option, existence and bequest.[10] Then, the portion of total annual benefits attributed to recreation use was removed and the remaining values in the option, existence and bequest categories were summed as annual preservation value. We believe that this procedure may lead to a resolution of the problem of possible double counting in preservation value studies discussed by Bishop (1982) and others. The procedure was designed to: (1) exclude the expected consumer surplus of recreation use from the measure of option value; and (2) include the separate existence and bequest values of both users and nonusers of the resource. Moreover, allocating preservation values into the three major categories of motivation in public goods consumption facilitates analysis of their separate association with distance from the resource, as illustrated by the final results.

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[10] The format was adapted from a 1980 survey of the recreation use and preservation value (option, existence and bequest demands) of wilderness protection in Colorado (Walsh, Gillman and Loomis, 1982). The authors reported that average annual preservation value to resident households increased at a decreasing rate, contingent on the amount of wilderness protected: $14 per household for 1.2 million acres; $19 for 2.6 million acres; $25 for 5 million acres. These nonuse preservation values accounted for nearly 50 percent of the estimated total benefits of wilderness protection in the state.

A. Literature Review

Previous applications of the contingent valuation method in studies of the preservation value of water quality have not addressed the issue of the effect of distance from the study site. Three studies have estimated aspects of the average total preservation value of water quality to residents of a city or river basin, one of which asked respondents to estimate each of the components of preservation value (option, bequest and existence demands) as distinct from expected consumer surplus of recreation use. At least four other studies have applied the contingent valuation approach to estimate the expected consumer surplus from recreation use of water quality, omitting any estimate of nonuse preservation values. Comparable estimates of the recreation use value of water quality have been obtained by applications of the travel-cost approach (Bouwes and Schneider, 1979; Sutherland, 1982); however, in the interest of brevity they will not be reviewed here.

Meyer (1974) used the contingent valuation method to estimate the preservation value of maintaining natural free-flowing water in the Fraser River system, British Columbia, Canada. A representative sample of 1,615 households residing in the province were interviewed in 1972. Resident households in the upper river basin were willing to pay an average of $223 per year for preservation of the river system. Households residing in the lower river basin were willing to pay somewhat more, although the estimate was considered less reliable. An attempt to develop a separate estimate of option value proved unsuccessful. Nonuse preservation values added 54 percent to the estimated benefits of salmon fishing in the basin.

Gramlich (1977) used the contingent valuation approach to estimate the total value of water quality to residents of the Charles River Basin. The author interviewed a representative sample of 165 residents of the Boston area in 1973. Willingness to pay annual taxes to improve water quality to natural occuring levels averaged $30 per household. Residents of Boston were willing to pay an additional $25 annually to improve water quality in other river basins throughout the U.S. The study was not designed to allocate the stated willingness to pay among recreation use and preservation values. Thus, the benefit estimates can be interpreted as each respondent's perception of a combination of recreation use, option, existence and bequest values. In a closely related study, Binkley and Hanemann (1978) used the contingent value approach to estimate the willingness to pay for water quality improvement in the Boston area as $2.07 per household visit to a water-based recreation site.

Greenley, Walsh and Young (1981, 1982) applied the contingent valuation approach in a study of the recreation use, option, existence and bequest values of water quality in the South Platte River Basin, Colorado. They interviewed a representative sample of 202 households residing in the river basin in the summer of 1976. Households reported maximum willingness to pay for each of the components of preservation value (option, bequest and existence demands) as distinct from expected consumer surplus from recreation use. The authors reported that 81 percent of resident households were willing to pay additional sales taxes of $57 per year for recreation use and $23 for option demand. Recreation users reported willingness to pay an additional $33 per year for existence value and $34 for bequest value, premised on the assumption that they would not engage in water-based recreation activities in the river basin. Nonuser households (19 percent of residents) were willing to pay an average of $25 per year for existence value and $17 for bequest value. Residents of the river basin were unwilling to pay additional amounts for water quality in other river basins in the state (Colorado, Arkansas, and Rio Grande Rivers).

Oster (1977) used the contingent valuation approach to estimate the recreation use value of water quality to non-resident tourists in the South Platte River Basin, Colorado. Ericson interviewed a representative sample of 141 households visiting Rocky Mountain National Park in 1973. Respondents ranked six color photos of varying water quality and rated each on a 100-point pollution scale. Tourist households were willing to pay $0.06 per day in additional entrance fees for each one unit increase in perceived water quality. For example, tourists would pay a daily fee of $3.60 per household to improve water quality from a pollution index of 20 to 80.

Sutherland (1982) used the contingent valuation approach to estimate the recreation use value of water quality in the northwestern region of the U.S. A sample of 364 individuals engaged in the water-based recreation activities of fishing, boating, swimming shoreline camping were interviewed in Idaho, Oregon and Washington in the summer of 1980. Average individual willingness to pay for water quality was reported as about $5.60 per trip. For the most part, these were short trips averageing 30-50 miles one-way except for camping which averaged 112 miles. A comparable estimate of the recreation use value of water quality was obtained from application of a regional travel cost model.

Although others have considered various aspects of the preservation value of water quality (Mitchell and Carson, 1981), the particular issue addressed here has not been studied, with perhaps one exception. Gramlich reported the effect of distance on willingness to pay for water quality by residents of the Boston metropolitan area. For example, households living one-quarter of a mile from the Charles River were willing to pay an average of 40 percent more for water quality in the river than those residing four miles away. Hours of recreation use of the river also was positively associated with willingness to pay for water quality. The distance coefficient was significantly related to recreation users willingness to pay for water quality but not nonusers. Since no respondent resided more than eight miles from the Charles River, the effect of distance was not extrapolated outside the range for which it was estimated.

B. Contingent Valuation Approach

The contingent valuation method used in this study was recently recommended by the U.S. Water Resources Council (1979) as providing an acceptable procedure for measuring the economic value of outdoor recreation and environmental quality. The interagency committee established procedures for surveying a sample of the affected population concerning their maximum willingness to pay contingent on changes in the availability of an environmental amenity such as water quality. The approach has been successfully applied to a number of environmental problems since its proposal by Davis (1963) twenty years ago.

A representative sample of 171 resident Montana households participated in a mail survey during the summer of 1981. Response rate was 61 percent after three mailings to a random sample drawn from current telephone directories of four major cities in the state: Kalispell, Missoula, Butte and Billings. These cities were selected because of their varing distances from the study area: 10, 115, 227, and 420 miles respectively. Pooling of data from the four cities and adjacent rural areas provided the necessary information to estimate the statistical association between distance and willingness to pay for water quality in Flathead Lake and River, holding constant the effect of all other variables in the function.

The willingness to pay question was presented in the following simple and direct format:

> Please keep in mind that the following question is a hypothetical experiment intended to provide an economic measure of how strongly you value the protection of water quality in the Flathead Lake and Rivers.

Assume that the only way to protect water quality in Flathead Lake and Rivers is for all people to pay into a special fund to be used exclusively for this purpose. What is the maximum amount of money your household would be willing to pay annually to protect water quality in Flathead Rivers and Lake? $___

People value the protection of water quality for several reasons. What proportion (percent of 100) of the highest dollar value you reported would you assign to each of the following purposes? Read the entire question first then answer each of four parts; together, they should total to 100 percent.

(1) Payment to visit Flathead Lake or River this year (in addition to travelling or lodging expenses). ____%

(2) Payment for the opportunity to visit this Lake or River in the future at the same level of water quality and fishing conditions. ____%

(3) Payment to preserve water quality in Flathead River and Lake. The value to you from knowing that good water quality exists here. ____%

(4) Payment to preserve water quality in Flathead River and Lake. The value to you from knowing that future generations will have good water quality. ____%

The replies indicate that households reporting positive values for water quality encounter little or no difficulty in allocating the amount among the four categories of value: recreation use, option, existence and bequest demands.

The literature identifies several possible sources of bias in application of the contingent valuation approach. These include: (1) strategic bias in which respondents may attempt to influence the study by over-or under-statement of actual values; (2) hypothetical information bias in which individuals may not consider the contingent market sufficiently realistic to provide values; (3) instrument bias in which respondents may reject the vehicle of payment, consider it unfair to pay to avoid damages inflicted by others, or possible error owing to the open-ended nature of the value question; and (4) sampling bias in which the population may not be fairly represented by a mail survey. This section reviews the available evidence on the likelihood that each of these possible biases may be present in this study. It will be shown that strategic bias, sampling bias, and possible bias arising from the open-ended nature of the value question are not likely to significantly influence the study results. However, the extent of zero response as a protest against the payment vehicle and/or hypothetical nature of the market is unknown, and it seems that this may represent a significant bias of the study results. Bishop and Heberlein (1979) concluded that the contingent valuation approach may overvalue or undervalue environmental amenities by as much as 60 percent. This seems to be a reasonable expectation in the present study.

There is a possibility that individuals may engage in strategic behavior, overstating true willingness to pay in order to encourage management agencies to protect water quality of the lake and river while avoiding actual payment of the stated amount, or understating values to discourage management agencies from levying taxes or user fees to construct and operate wastewater treatment facilities. In this case, respondents were encouraged to give accurate answers to the value question which was presented as a hypothetical experiment intended to provide an economic measure of how strongly they value the environmental amenity. Thus, few respondents would feel that their answers could affect real world outcomes. The provision that all people would pay was introduced to minimize the free rider problem. If respondents biased their willingness to pay responses, a requency distribution would show a bimodal clustering of values at abnormally high and/or low levels. Distribution of the values in Table 1 does not indicate abnormal behavior, suggesting there was little or not strategic bias of the study results.[11] This is consistent with the findings of Schulze, d'Arge and Brookshire (1981) who reviewed six recent contingent value studies and concluded that "strategic bias in revealing consumer preferences is not likely to be a major problem."

There is a possibility the population may not be fairly represented by a mail survey to which 39 percent of the sample did not reply. The relevant question is whether nonrespondents should be assumed to hold zero values. We believe that nonrespondents may have approximately the same average values as respondents. Statistical tests showed no significant difference between values reported by early and late respondents. This is consistent with the findings of Wellman et. al. (1980) that differences were negligible between early and late responses to several mail surveys of outdoor recreation preferences. Thus, tentatively we conclude that a response rate of 61 percent may represent the population as well as would a response of 80-100 percent. Moreover, characteristics of the sample with respect to income, age, education and household size were very close to the general population of Montana as reported in the 1980 Census. Under-representation of women (35 percent) was corrected in the computations. Thus, it was considered unnecessary to contact a sample of nonrespondents

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[11] A few respondents reported very high willingness to pay, three between $500-$999, two $1,200 with the maximum $3,000 per year. These outliers resulted in large residuals and a significant reduction in the overall explanatory power of the regression model. However, examination of the individual questionnaires did not indicate that the high values were abnormal so they were included in the analysis.

TABLE XVIII

FREQUENCY DISTRIBUTION AND MEAN VALUE OF EXPECTED CONSUMER SURPLUS FROM RECREATION USE, OPTION, EXISTENCE AND BEQUEST VALUE OF WATER QUALITY, FLATHEAD LAKE AND RIVER, MONTANA, 1981.

Value Categories	Number of Respondents				
	Option Value	Existence Value	Bequest Value	Recreation Use Value	Total Value
Zero	90	80	78	101	73
$0.01 - 1.99	11	11	20	11	1
2.00 - 9.99	32	41	27	31	24
10.00 - 24.99	21	34	28	20	16
25.00 - 49.99	8	9	12	4	14
50.00 - 99.99	6	6	9	2	24
100.00 - 199.99	2	1	3	1	7
200.00 - 299.99	1	2	0	1	5
300.00 - 499.99	0	1	4	0	2
500.00 - 999.99	0	1	1	0	3
1,000.00 and above	0	0	0	0	2
Mean Values	$10.71	$19.88	$26.37	$7.37	$64.16

by phone nor to conduct a fourth certified mailing, as suggested by Dillman (1978) in a guidebook for mail surveys. To do so would impose a substantial burden on persons in the sample who may prefer not to participate and who consider repeated requests an intrusion on their privacy.

There is a possibility that the open-ended direct question used in this mail survey may not provide as accurate an estimate of value as the interactive bidding technique. Heads of households were asked to write down their maximum willingness to pay annually for the preservation of water quality in the Flathead Lake and River system. While both the open-ended and iterative approaches are recommended by the Water Resources Council (1979), the iterative procedure has been preferred because it is specifically designed to assist respondents as they approach the point of indifference between having the amount of income stated or the environmental amenity. However, the use of open-ended questions in mail surveys may have several advantages of their own. The questions can be answered at home and at a time convenient to the respondent. Household members can engage in extensive discussion before giving a dollar amount. There is no possibility that an interviewer may bias the answers, nor that a starting point or interval bias might be introduced. In the iterative bidding procedure, the starting bid may suggest the approximate range of appropriate bids, and a respondent may become irritated with a lengthy bidding process. In this case, the mail questionnaire was short, requiring only a few minutes to answer a total of 12 questions.

We believe that the open-ended direct question may provide results similar to the iterative bidding technique recommended by the Council. Walsh and Gillman (1982) asked approximately one-half of a sample of 280 forest recreation users in the Rocky Mountains of Colorado an interative bidding question, one-fourth an open-ended direct value question, and one-fourth to write down their maximum willingness to pay in a mail-back questionnaire. Results showed no significant difference in the values reported at the 95 percent level of confidence. Moreover, variations of the open-ended question have been used successfully in mail surveys of the contingent valuation of waterfowl hunting (Hammack and Brown, 1974; Bishop and Heberlein, 1979) and of wilderness recreation and preservation values (Cicchetti and Smith, 1973; Walsh, Gillman and Loomis, 1982).

There is a possibility that the hypothetical information provided on the contingent market may not be sufficiently close to the experience of individuals to allow them to provide realistic values. In this study, the hypothetical situation was designed to be as realistic and credible as possible. The willingness to pay question was preceeded by a statement that payment of the stated amount would protect water quality in the study areas. And nonpayment would result in substantial damage to water quality. Most residents of the state were aware of water pollution in several areas of the state as a result of past and current coal mining with prohibitive cost of rectifying the damage. The iminent possibility of expanded coal mining and the probability of substantial damage to water quality provided a realistic setting for investigating the empirical significance of preservation values.

There is a possibility that respondents may reject the method of payment or consider it unfair to apply to avoid damages inflicted by others. In this study, possible payment vehicle bias was minimized by asking respondents to report their willingness to pay into a special fund to be used exclusively for the purpose of protecting water quality in the lake and river. This relatively neutral method of payment was selected over alternatives such as an entrance fee, sales tax, or electric bill in an effort to avoid emotional reaction and protest against the method. Also, respondents were asked to assume that this method of payment was the only possible way to finance protection of water quality. This was designed to minimize the incidence of zero response as protest against the particular method of payment. However, the extent of payment vehicle bias is unknown. No questions were asked to determine if some zero values represent rejection of the payment vehicle or hypothetical market. A recent survey of wilderness values using an identical payment vehicle and a similar hypothetical market reported that zero protest bids represented nearly 10 percent of the sample which were eliminated from calculations of population values, as recommended by the Council. If protest bids represented 10 percent of the Montana sample (17 responses), the effect would be to increase the average values of water quality reported in Table 1 by approximately 11 percent.

It is notable that objections to the contingent valuation approach have been primarily theoretical, as empirical evidence of systematic bias is at best inconclusive. Davis, who pioneered the method in a study of the recreation benefits of the Maine woods, concluded that the reported values were not significantly different from those obtained by the market-related travel cost approach (Davis, 1963; Knetsch and Davis, 1966). Randall and associates developed refinements in the contingent valuation technique and presented a persuasive case for its effectiveness in the valuation of environmental quality. They studied the benefits from improved air quality and other environmental amenities in the Four Corners area of New Mexico (Randall, Ives and Eastman, 1974) and the Glen Canyon National Recreational Area (Brookshire, Ives and Schulze, 1976). They found no measurable strategic behavior by environmentalists compared to other respondents. Replication of the studies resulted in similar values. Bohm (1972) conducted a controlled experiment comparing five alternative measures of willingness to pay for a public good, including actual payment in cash of the stated willingness to pay. He found no significant difference in values reported by five groups, each presented with an alternative willingness to pay format. Bohm (1979) shows that the theoretical objections to the contingent valuation approach are resolved by application of an interval method. Two benefit functions would be derived, based on minimum and maximum incentives to misrepresent willingness to pay. The midpoint of the interval would represent the most acceptable value.

The willingness to pay measure of the preservation value of water quality was selected over the alternative, willingness to sell or accept compensation for reduced water quality. The appropriate question depends on the resource decision to be made. Congress determined that water pollution rights are not for sale. Thus, the question of what level of compensation would be required to allow the general public to remain no worse off than before is of only peripheral interest. A number of studies including Bishop and Heberlein (1979) have found that willingness to sell values including actual cash sales are considerably higher than willingness to pay, whether the latter is measured by the contingent value or the travel cost approach. This is the expected result, as willingness to pay would be constrained by limited household income and time budgets as well as other variables (Gordon and Knetsch, 1979). More realistic estimates of value are expected under these constraints. The acceptance of compensation would increase the respondent's level of income and result in value estimates which are unrestrained by the utility of dollars normally earned as income.

C. Econometric Model

Preservation values are estimated by (1) developing an appropriate econometric model of willingness to pay by households included in the survey data, and (2) aggregating across households in counties of Montana and in neighboring states and provinces. The usual procedure in contingent valuation studies is to estimate a model of the general form recommended by the Council. Willingness to pay (WTP) by decision-making unit i for water quality motive k is written as

(VI.1) WTP_{ik} = f(VISIT, SEX, AGE, HS, EDUC, INC, MAIL, DIST)

where the independent variables are defined as:

VISIT = A dummy variable = 1 if someone in the household visited the area at least once during the year.

SEX = A dummy variable = 1 if male, 0 if female.

AGE = Age in years.

HS = Number of people in the household.

EDUC = Level of education in years.

INC = Annual family income before taxes in 1980.

MAIL = A dummy variable = 1 if first mail response and = 0 if second mail response.

DIST = Distance in one-way miles from the study area.

The primary objective is to produce a statistical willingness to pay function with reliable estimates of the structural parameters, particularly that of the distance variable. Various specifications, such as double-log, semilog, and linear, were estimated but with generally unsatisfactory results. In an effort to develop a significant statistical relationship between preservation value and distance, an alternative two-stage model is specified. First, a visit model is postulated where the probability of visiting the study area is linearly related to distance and other significant demographic variables. Then a preservation value model is postulated where willingness to pay for option, existence and bequest demands is linearly related to the probability of visiting the study area. Finally, computational equations which express willingness to pay as a function of distance are obtained by substituting the visit regression equation into each of the willingness to pay equations.

The regression results for the probability of visiting the study area are[12]

(VI.2)

$$VISIT = \underset{(2.906)}{0.559} - \underset{(-9.397)}{0.0018}DIST - \underset{(-2.254)}{0.0042}AGE + \underset{(3.188)}{0.0334}EDUC.$$

$$R^2 = .42 \quad n = 167$$

The distance coefficient is significant at the 0.99 level and indicates that the probability of visiting the study area declines by about 0.18 with each 100 miles increment in distance. Education of the head of household is positively associated with the probability of visiting the study area and age is negative as expected. Both of these demographic variables are significant at the 0.95 to 0.99 level. Other variables such as household income are not significant at the 0.95 level. The overall explanatory power of the model is considered satisfactory for cross-sectional data on household consumption with an $R^2 = 0.42$.

The regression results for each of the willingness to pay functions deleting distance are

(VI.3)

$$WTP_{opt} = \underset{(1.605)}{-16.645} + \underset{(1.749)}{8.054}VISIT + \underset{(2.200)}{1.717}EDUC \qquad R^2 = .063, \quad F = 5.613$$

(VI.4)

$$WTP_{ext} = \underset{(-0.480)}{-11.616} + \underset{(2.194)}{23.469}VISIT + \underset{(0.809)}{1.466}EDUC \qquad R^2 = .041, \quad F = 3.593$$

(VI.5)

$$WTP_{bqt} = \underset{(-0.490)}{-14.236} + \underset{(2.485)}{32.035}VISIT + \underset{(0.839)}{1.832}EDUC, \qquad R^2 = .051, \quad F = 4.471$$

where each F statistic is significant at the 0.90 percent level. The coefficients for probability of visiting the study area are significant at the 0.90 to 0.95 level and indicate that those who visit the study area are willing to pay approximately \$8 more than other households for option value, \$23.50 more for existence value and \$32 more for bequest value. Education of the head of household is

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[12] Equation (VI.2) has a dichotomous (zero or one) dependent variable, which produces unviased regression coefficients, but a hereroscedastic disturbance term that nullifies the t tests . Smith and Munley (1978) compare the use of OLS to logit and probit models and found little difference in the predictive performance of various models or in their ability to identify key variables.

positively associated with willingness to pay. Other demographic variables are not significantly associated with willingness to pay at the 0.95 level and are omitted. The overall explanatory power of the model is low with an adjusted $R^2 = 0.04$ to 0.06. However, the level of significance of the visit variable is of more concern than the magnitude of the coefficient of determination.

Finally, computational equations expressing willingness to pay as a function of distance are obtained by substituting the visit equation into each of the above willingness to pay equations. The resulting final equations are

(VI.6) $WTP_{opt} = 13.188 - 0.014DIST$

(VI.7) $WTP_{ext} = 24.490 - 0.0422DIST$

(VI.8) $WTP_{bqt} = 36.857 - 0.0577DIST$

The intercepts of these equations can be interpreted as the expected willingness to pay per household due to the composite influence of all variables other than distance. The distance coefficients are negative for each of the preservation values, indicating that willingness to pay for option value decreases at a rate of 1.5 cents per mile compared to decreases of 4.2 and 5.8 cents per mile for existence and bequest value. Substituting the sample mean distance of 182 miles into these equations yields an estimated option value of \$10.55 compared to existence value of \$19.80 and bequest value of \$26.36 which are virtually identical to the sample means presented in Table XVIII.

It may be tentatively concluded that the relationship between preservation values and distance in this case is a function of whether the household visited the study area. Specifically, the closer a household resides to the study area the greater the probability of having visited the area in the past. Visitors apparently acquire an appreciation for water quality in addition to its recreation use value. The knowledge gained by visiting the area is positively associated with willingness to pay for the preservation values of water quality.

Gramlich and Greenley et. al. found a similar relationship between user and non-user preservation values.

D. Aggregate Preservation Value

The purpose of this section is to illustrate the effect of using the regression coefficients for distance to extropulate the survey results to the appropriate regional population. The geographic boundary of households with positive preservation values for water quality at the study site is obtained by dividing the regression coefficients for distance into the constants of equations (VI.6), (VI.7) and (VI.8). The procedure results in very low values for households living beyond 640 miles. This boundary estimate seems reasonable because the study site attracts recreation visits mostly from a regional population. Few households living beyond the region either visit or have knowledge of water quality in the Flathead Lake and River.

Table XIX illustrates the two-stage estimation of aggregate willingness to pay for the preservation value of water quality from Eq. (VI.6), (VI.7) and (VI.8). The three computational equations were used to estimate aggregate willingness to pay for the population of each county in Montana, six other states and three provinces in Canada (termed zones). Mileage from the main population centers of each zone to the study site was obtained from highway maps. Substituting each distance estimate into the computation equations resulted in an estimate of willingness to pay per household. The resulting values for each zone were summed to obtain the estimated aggregate preservation value for the relevant regional population.

Aggregate preservation value is shown to be $97.3 million annually based on the two-stage regional approach. This estimate represents a substantial increase in value compared to the approach of past studies which estimated the average preservation value for the population of a city, river basin or state.

TABLE XIX. AGGREGATE ANNUAL PRESERVATION VALUES FOR FLATHEAD LAKE AND RIVER, MONTANA, 1980.

States and Provinces	Mean Distance	Preservation Values ($1,000)			
		Option	Existence	Bequest	Total
Montana	184	$ 2.671	$ 4,737	$ 6,166	$13,574
Washington	416	11,020	15,268	19,816	46,104
Oregon	735	2,511	0	0	2,511
Idaho	611	1,404	544	527	2,475
North Dakota	845	213	0	0	213
South Dakota	971	0	0	0	0
Wyoming	712	476	0	0	476
Total, States		$18,295	$20,549	$26,509	$65,353
British Columbia	558	$ 4,192	$ 3,211	$ 3,850	$11,253
Alberta	403	4,501	6,412	8,345	19,258
Saskatchewan	637	1,214	178	39	1,431
Total, Provinces		$ 9,907	$ 9,801	$12,234	$31,942
Grand Total		$28,202	$30,350	$38,743	$97,295

For example, multiplying the sample means for option, existence and bequest values from Table XVIII by the number of Montana households results in an aggregate preservation value of only $14.8 million annually, 85 percent less than the total regional value. Moreover, Table XIX shows that the regional approach results in a somewhat lower estimate for Montana households, reflecting the influence of eastern Montana residents living 450-500 miles from the study site.

Including the effects of distance represents an improved basis for estimating the preservation value of water quality. Whether the two-stage or direct empirical association between distance and willingness to pay is used depends on the level of statistical significance obtained. When the direct regression coefficients for distance are used, aggregate preservation value is estimated as $92.6 million annually for the regional population. This is within 5 percent of the two-stage procedure, suggesting that both approaches provide similar results. However, in this case the direct statistical association between distance and willingness to pay is not as reliable as obtained in the two-stage procedure.

The point estimates of preservation value presented in Table XIX are subject to a number of limitations. We presume that preservation values are not a function of geographic boundaries, including state and national boundaries. By sampling only Montana residents, this hypothesis could not be tested. A large proportion of the sample (45 percent) reported that they were unwilling to pay for the preservation value of water quality in the study area. But the proportion of these zero responses which represent rejection of either the payment vehicle or the hypothetical market is unknown. As a result of these and other possible biases discussed earlier in this paper, the contingent valuation approach used here may under or over-value the preservation value of water quality.

In addition to the economic measures of preservation value, there may be long-run ecological values that are not included. It is difficult for biologists to predict what these might be let alone measure and incorporate them into an economic benefit estimate. For this reason, it seems the economic values represent a conservative estimate of the social value of protecting fragile aquatic environments. The inability of economic analysis to place a dollar value on unknown ecological effects should be recognized in making decisions which affect water quality.

E. Conclusions

This section addressed the problem of estimating the effect of distance on the preservation value of water quality at a recreation site. Specifically, it was shown that option, existence and bequest demands for water quality decline with distance from Flathead Lake and River, Montana. The effect of distance on preservation value was estimated using regression analyses where the effect of distance was considered both directly and indirectly through its effect on visits. Although the household survey data contain large and unexplained variations, we identified a significant empirical association between reported willingness to pay and distance from the study site. An extrapolation of this association to the relevant regional population indicates a substantial aggregate preservation value of the study area. Even a modest and declining willingness to pay per household becomes a very sizeable number when aggregated across the total number of households in seven states and three Canadian provinces. Results of the sample survey suggest that the recreation use value of water quality at the study site is dwarfed by comparison with preservation value.

The regional approach introduces the geographic extent of preservation values into the analysis and thereby improves measurement of the preservation value of water quality. Past studies have estimated average preservation value of water quality to the population of a city, river basin, or state without reference to the effect of distance from the study site. In the absence of information on the extent of regional preservation benefits, aggregate benefits may have been underestimated and insufficient resources allocated to protection of water quality. Thus, it is proposed that future preservation value studies adopt a regional approach to estimate the boundary of significant positive preservation values of particular sites. Further research is recommended to test the general application of the approach to analysis of the preservation value of other aspects of environmental quality.

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